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a magazine devoted to progress in communication engineering

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SOME RECENT ADVANCES IN THE ECONOMY OF ROUTING CALLS IN NATIONWIDE DIALING*

By IMRE MOLNAR

Project Engineer, Automatic Electric Company

SYNOPSIS: *Regional toll dialing—major technical requirements for nationwide dialing—universal numbering plan—alternate routing—varieties of intertoll switching equipment—Strowger-type switching center in British Columbia — "FW-1" Intertoll switching system.*

Major Considerations in Nationwide Automatic Toll Switching

THE unprecedented growth in telephone stations and the demand for toll telephone service in the United States and Canada since 1945 have created a strong economic pressure towards mechanization of toll operation on a continent-wide scale. The ultimate goal of complete mechanization can, naturally, be achieved only in progressive steps spread over several decades—the first phase aiming at operator toll dialing, and the second phase at subscriber toll dialing, with both phases overlapping at times.

Toll dialing has been practiced on a limited regional scale in the United States for many years, by both operators and subscribers, and among both Independent and Bell System telephone companies. However, it is only recently that the telephone industry has devised and embarked upon an integrated plan for toll dialing which will embrace all of the United States and Canada. At the present time, about half of the long distance toll calls are dialed by the originating operators,

*A paper presented at the AIEE Fall General Meeting, Chicago, Ill., October 11-15, 1954. Published by permission.

while the proportion of subscriber dialed long distance calls is still negligibly small. In short-haul toll traffic the great majority of calls are dialed either by operators or by the subscribers.

Integrated subscriber toll dialing networks have been serving for many years in several European countries. Such networks have been working in Southern Germany for over 25 years; others are in operation in Belgium and Holland, while toll traffic is now dialed by subscribers over all of Switzerland. Much can be learned from their collective experience, but however impressive their technological progress may be, an integrated toll dialing plan for the whole North American continent has required many new approaches, due partly to the types of service given here by telephone companies, partly to the telephone habits of the public and partly to the very magnitude of the problem. It should be borne in mind, for instance, that the area of Switzerland is two-thirds that of West Virginia, that the total number of telephones there is about the same as in the city of Detroit, and that the number of telephones in the United States and Canada is almost twice that of the rest of the world together.

To establish a toll dialing plan involves a multitude of prerequisites, of which the following are the more obvious:

(a) *Toll dialing circuits.* Such circuits must naturally be capable of transmitting dial pulses and other supervisory signals. They must be reliable, reasonably free from signal distortion, and immune from disturbances which might cause false signals or service disruptions, particularly when used in a subscriber toll dialing network.

(b) *Automatic central office equipment.* Toll dialing assumes that the central office at the point of destination is converted to automatic operation, though occasionally such calls may be terminated in call indicator type manual offices. For subscriber toll dialing the originating office must likewise be automatic and the subscribers' dials must be of a suitable type.

(c) *Automatic intertoll switching equipment.* At intermediate and terminating points, automatic switching equipment must be provided for through switching of toll calls and for switching toll calls into local automatic equipment as well as to special service equipment.

(d) *Transmission means.* The toll circuit plant must meet the requirements of the prescribed transmission standards regardless of the various types of intertoll circuits, intertoll switching equipment, and the various routes and number of switching points for the same destination.

(e) *Numbering plans.* Suitable numbering plans must be established for all subscribers who are to receive toll calls over the intertoll dialing network, and suitable numbering plans must be established for routing and switching such calls through the toll plant.

(f) *Circuit provisions.* With automatic routing of toll calls a higher speed of service and therefore a more liberally engineered toll plant is required than with purely manual switching. When toll calls are to be dialed by subscribers, the provision of the toll plant must approach the virtual no-delay performance of local switching.

(g) *Toll ticketing means.* For subscriber toll dialing means must be provided for automatic registration of the toll charges and means for transferring these charges to the subscriber's account. The introduction of such automatic toll ticketing equipment makes it economically feasible to introduce equipment to provide special routing and switching functions, over and above those required for operator toll dialing.

In addition to the above items there are a large number of others, less obvious but nonetheless important. They may be of a technical nature such as the provision for intercept service, or purely administrative such as public relations, or a combination of both such as directory information. Item (b) does not require further discussion; item (a) has been extensively treated in technical literature and there will, no doubt, be further improvements before completely satisfactory techniques are firmly established; item (d) is in a state of fluidity and great advances both in general standards as well as in improved means can be expected[1]; items (c) and (e) will be the subject of this paper which will deal with new and simplified approaches; item (f) will be briefly touched upon; item (g) is outside the scope of this paper inasmuch as it concerns only the ultimate objectives of subscriber toll dialing and these can be superimposed upon the structures discussed here.

The numbering plan, as devised by the Bell System, contemplates that ultimately every tele-

phone subscriber in the United States and Canada will be assigned a number which will be different from the telephone number of any other subscriber. Such numbers will uniformly consist of ten digits, the first three of which will designate the numbering plan area, the next three the central office, and the last four the subscriber's number in the central office. It is further contemplated that ultimately for routing of calls outside the calling subscriber's own numbering plan area all ten digits will be required; that for calls within that numbering plan area only the last seven digits will be dialed, though in some cases seven digits will suffice for calls between certain offices in two adjacent areas having a high community of interest; and that calls within smaller communities may also be established by the dialing of the last five or four digits only.

The United States and Canada, taken together, are divided into about 90 numbering plan areas with other areas added where the present subdivision proves to be inadequate. A state or province includes at least one whole numbering plan area while many states or provinces have to be subdivided into several—as many as six—independent numbering plan areas. Each area code has 0 or 1 as its second digit, while the first and third digits are numbers from 2 through 9; therefore, with this scheme, it is possible to increase the number of areas to 128. By this numbering arrangement, in contrast to the central office codes, the toll switching apparatus can distinguish between calls destined to points within or outside of the numbering plan area.

To each central office within an area a distinct three-digit code is given consisting of the numerical equivalent of the first two letters of the central office name plus one numerical digit from 1 through 0. The same central office codes may be reused in many or all of the 90 numbering plan areas. At the present about half of the total telephones are operated on this so-called 2-5 numbering basis. The maximum theoretical number of central office codes per area is thus 600, excluding the 40 codes set aside for radio-telephone service. The practically available number of codes, however, is considerably less, for a block of codes is required for the so-called toll center codes, further codes are used up when conflicts are to be avoided where seven-digit dialing is required between adjacent numbering plan areas, other codes may have to be omitted due to undesirable central office names, and codes may also be sacrificed for the sake of economies in trunking and switching equipment. At present it is contemplated that a separate code will be required for every central office even though it may serve only a few stations, particularly if the office represents a distinct toll rate center, since it is assumed that it will be practical only for a machine to distinguish toll rates on a three-digit basis.

The last four digits represent the station number within a central office assuming central office units from a few stations up to 10,000. At present there are a large number of central office units in service having five-digit station numbers which, unless blocks of central office codes are to be used up, result in eleven-digit toll numbers. Such number assignments are common in larger terminal-per-line central offices, and also in high-multiple manual boards. The future of these eleven-digit numbers is still uncertain. It is felt that when subscriber toll dialing is introduced on a wide scale it would be confusing for subscribers to dial seven-digit or ten-digit numbers in most cases (and perhaps five-digit local numbers as well) and eight or eleven digits for some destinations. On the other hand, if squandering of the already limited number of central office codes is to be avoided, the elimination of such numbers might in many cases be unduly costly because this requires conversions in the local switching equipment. In common control types of intertoll switching systems and toll ticketing equipment, mixing of ten-digit and eleven-digit numbers causes some, though not excessive, circuit complications which should preferably be avoided. In direct pulse controlled intertoll switching systems, the number of digits is inconsequential, and in some cases such mixed numbering has advantages in flexibility and economy of trunking. How this problem will ultimately be disposed of cannot now be predicted; with operator toll dialing mixed numbering is no problem at all, and with the limited extent of subscriber toll dialing which will be probable in the next few years such eleven-digit destinations can be excluded and left to operator completion if desired. However, in general, there is a tendency by engineers to underestimate the competence and willingness of the general public, just as years ago it was thought that automatic telephone systems were

impractical because subscribers would be unable to dial their calls and would always need the assistance of an operator.

The theoretical capacity of the North American numbering system is 768 million station numbers, which is fourteen times the present total stations in the United States and Canada. We have seen, however, that for practical purposes this picture is misleading and we must look at it from a different angle. The theoretical maximum number of office codes which can be accommodated by this plan is 76,800 but practical considerations will limit this to a much lesser number, say on the order of 50,000. Since the present number of central offices in the United States and Canada is about 22,000 we still have a comfortable 150% margin, but only if the patterns for both local and toll trunking are very carefully laid out in an integrated plan which avoids waste in central office codes, and this will be possible in some cases only at some additional cost in plant and equipment. Actually, with the present 90 numbering plan areas the theoretical maximum number of office codes is 54,000 which, considering practical limitations, gives us a less comfortable margin to work with. This problem is of particular importance to independent telephone companies since two-thirds of the central offices are outside the Bell System.

We have assumed in the preceding discussion that a universal numbering plan is a prerequisite for toll dialing, which means that the same number is dialed to reach a certain station no matter where on the continent the call originates; however, some might question the validity of this assumption. Actually, even the ultimate plan does not contemplate such uniformity. A subscriber in a small town should and will be able to reach a station in his community by dialing a four-digit or five-digit number though he can also reach the same station by dialing the full seven digits; but if he calls from a nearby town he must dial the full number. Furthermore, a subscriber in Chicago, for example, will reach any station in Chicago or in any of its suburbs, or any one in the same numbering plan area, or any one in Gary, Indiana, another numbering plan area, by dialing a seven-digit directory number, but must prefix one of the several Illinois area codes if he calls a station in Illinois outside his own area. It is difficult to see how this can be avoided by any practical system. But we might as well realize that subscribers and PBX operators must have available a certain amount of routing information for making long distance calls even though this will be very simple; and for frequently called destinations, which represent a large portion of toll traffic, the routing information can readily be memorized.

In some of the European countries where subscribers dial their toll calls, extensive use is made of routing codes consisting of various numbers of digits, apparently with satisfactory results. However, for subscriber toll dialing a universal numbering plan, in the sense described in the preceding paragraph, appears to be the more desirable solution if it can be accomplished at a reasonable cost. "Reasonable" is a loose word to use in the guidance of engineering design, and universal numbering does cost some money. Subscriber toll dialing is still in its infancy and what its ultimate cost will be remains to be seen. However, huge investments in toll plant are already being made towards that end, and in spite of generally rising price levels and increasing operating costs it has been possible to reduce long distance toll rates. While this fact in itself is insufficient to justify every phase of the program, it provides at least some evidence that the cost for the overall approach is not yet unreasonable.

In operator toll dialing either direct point-to-point circuits or directing codes are used, followed by the subscriber's directory number. The directing codes might be arbitrary to the point of being governed by the trunking pattern of the switching equipment; they might resemble the national codes though they were chosen by similar considerations; or they might coincide with the national codes of the universal numbering plan. During the next few years, operators will be able to dial more and more calls by using the national codes, but it is not expected that this program will be substantially complete for at least another ten years. Whether all of the arbitrary routings by operators can ever be eliminated or whether this would necessarily be desirable is open to debate. When we discuss nationwide toll dialing, we instinctively think of cross-country long haul traffic and are apt to forget that the community of interest usually declines with distance and that the large volume of toll traffic remains close by, often within the same numbering plan area. There are at present about

2500 toll centers and only about 70 of these, according to present plans, will become control switching points. The operators in the other toll centers will handle large volumes of traffic over direct trunks and alternate routes not passing through control switching points. Advantage is taken at such locations of the inherent simplicity and flexibility of Strowger-type intertoll switching equipment without common control to build up multi-switched connections at low cost and at maximum speed. Operators quickly memorize the frequently used routing codes, while others are readily found in their flip-flop references or key-shelf bulletins to which they must often refer for other purposes also. With careful planning of code assignments these routing codes can in many cases coincide with the national numbering, in which cases further simplification in switchboard operation will result. Gradually a point of diminishing returns may be reached and the remaining items of traffic handled by arbitrary routing assignments rather than by added equipment with its increased complexity and cost.

In addition to routing calls to telephone subscribers, the intertoll switching plan must provide for routing calls to various operators and to various plant test facilities. At present it appears that such routings, if feasible, should be restricted to calls dialed by operators. Special number assignments are made for such service codes consisting of three or four digits or, in some cases, five digits, the special distinction for such codes being that all of them have "1" as the first digit. When such service calls are routed to toll centers, a so-called toll center code is prefixed to the service codes. The toll center codes are similar to the regular central office codes; in multi-office areas a toll center code is assigned which does not conflict with any office code but which preferably ends with "0"; in smaller toll centers the code may be the same as the central office code. In toll centers which are not control switching points, the toll center codes are omitted and such service calls are switched upon the first digit "1" of the service codes.

With the introduction of toll dialing by operators, it became apparent that in order to obtain the maximum benefit from this method a higher speed trunk service is required than with the previous ringdown operation, partly because delays at intermediate switching points with consequent repeated attempts were to be avoided. For most long distance routes the objective was a busy hour trunk speed of 30 seconds, with some routes engineered at a better and a few others at a worse grade of service. Special provisions were devised at switching points to indicate to the originating operators the state of congestion and to expedite traffic, but in general more liberally engineered trunk groups were required to obtain the desired service objective. On the other hand, toll dialing permits the elimination of unprofitable direct circuits by the substitution of more switching points than are permissible with manual switching; thus, by combining several independent traffic paths into one circuit group, we obtain a higher efficiency per trunk and the cost of increased speed of service is reduced.

With subscriber toll dialing, a still better grade of service is required since if the customer is too often blocked on the route to his destination, he will get discouraged and pass the call to an operator. Many years of experience in local operation provide good indication of the grade of service customers demand, and the engineering of toll circuit provisions for subscriber toll dialing can benefit from this experience. To approach the interlocal grade of service in toll operation would be prohibitive with the present cost of toll circuits, and it could well be that long distance subscriber toll dialing would have been impossible if multi-switching in dial operation had not offered increased economies.

Toll operation with alternate routing and multi-switching has been practiced probably as long as congruous toll networks have existed. Automatic alternate routing in local operation has been practiced for many decades even when it was not known by this name. Operator toll dialing is possible with or without automatic alternate routing. The originating operator can see at a glance when the principal route is busy and can choose at once one of the prescribed alternatives, and can do this at no loss of speed and at a lower cost than by automatic means. Visual alternate routing has the advantage of flexibility by permitting instantaneous changes in the assignment of alternate routes when traffic or plant conditions require such changes on short order, without administrative problems or interference with the switching

equipment. It has the further advantage that the operator knows the route the call has taken in case this information is needed for arriving at toll settlements. Alternate routing can similarly be treated by the originating operator at intermediate switching points though automatic alternate roui ing at such points has some definite advantages. Alternate routing of calls for subscriber toll dialing without automatic means appears to be impractical.

Considerations governing automatic alternate routing from the traffic engineer's point of view were described in a recent article[2]. It appears that under the existing conditions substantial economies can be achieved with multi-switching and automatic alternate routing for the grade of service required in subscriber toll dialing as compared with a system without alternate routing; however, whether for the volume of traffic in, say ten years from now, these advantages will remain the same or become greater or less seems at the moment to be unpredictable. Even the magnitude of savings achievable today cannot be evaluated reliably due to the inadequacy of statistical methods and lack of standards on which comparisons can be based; such evaluation must await the appearance of sufficient empirical data.

The uncertainty of the situation to be faced ten years from now is even more pronounced if we consider that we have no idea about the degree of progress which will be achieved in technical development, particularly in regard to further cost reductions for transmission means. However, judging from what has happened in the past ten or fifteen years we have every reason to believe that such progress will be considerable. The whole concept of transmission media has changed. Not so long ago the cost of a toll circuit was largely governed by so many miles of copper and lead and so many poles and crossarms. Since then the importance of these items has become progressively reduced, because they have been replaced by concentrated components in the form of filters, condensers, vacuum tubes, etc. High usage circuits are established between two toll centers when such circuits are more economical than any other available route; so it might well be that at some future date the cost of toll circuits will compare favorably with the switching cost, and to provide direct circuits will become more attractive than alternate routing; or at least the proportion of traffic which is to overflow from the high usage circuits may be reduced.

The above considerations must not lead us to conclude that automatic alternate routing is not justified or that it will shortly become obsolete or that engineering developments for such systems are unjustified. There can be no doubt that in many cases automatic alternate routing presents a considerable saving, and that this will remain true in the foreseeable future. Therefore, there is a real need for simple automatic routing systems at the lowest possible cost. Besides being simple and inexpensive, they should be flexible and self-contained, with the provision that they can be added or removed whenever conditions so require. Such an arrangement, as part of a new intertoll switching system, was described in a recent AIEE Conference paper[3].

Toll Switching Plans for the Canadian Province of British Columbia

The preceding discussion has dealt with some of the most important aspects of nationwide toll dialing; the remainder of the paper will describe simplifications in the routing of toll traffic as incorporated in the recently developed intertoll switching system referred to in the previous paragraph. Since at the present time, and for some years to come, the great majority of toll calls will be extended by operators, our discussion will relate mainly to operator toll dialing; the routing of subscriber dialed toll calls is incorporated in the automatic toll ticketing equipment which can be superimposed on this arrangement.

For the automatic switching of toll traffic in this country either Strowger-type or crossbar-type of switching equipment is employed. Both systems are now fully developed to provide all features required for intertoll switching. The Strowger equipment might be straightforward dial pulse controlled, wholly of the common control type, or a combination of the two with common control being used only as far as it is economically justified. Though dial pulse controlled crossbar switching systems have been used abroad to a limited extent, the developments here and abroad during the past ten to fifteen years have demonstrated that the full potentialities of crossbar equipment can be exploited only by complete common control. Therefore all crossbar equipment used in the

United States is so designed. Strowger equipment has been well-known to telephone people for many years, while large scale use of crossbar systems is comparatively new to most of them, even though sporadic applications of crossbar equipment have appeared for at least 35 years. Therefore recent technical publications have to a large extent been devoted to descriptions of the less familiar features of crossbar equipment, while the advances in Strowger techniques as applied to intertoll switching have apparently been taken for granted. In the following we shall describe the planning of a large intertoll switching network employing Strowger-type equipment exclusively, and taking full advantage of its potential economy, simplicity and flexibility. Because there are many areas with similar characteristics, our discussion will be best illustrated not by hypothetical examples, but rather by factual data, projected to a target date about five years hence.

The Canadian province of British Columbia represents one numbering plan area (604) in continent-wide toll dialing. There is one metropolitan area, Vancouver, with 32 central office units and a total of 263,000 stations. Several of the central offices will be manual for a number of years to come, with incoming toll traffic to be completed through call indicator type equipment. Another multi-office area, Victoria, has 7 central office units and 50,000 stations. There are 41 exchange areas with from 1000 to 10,000 stations each, single office or multi-office. The total number of central offices in the province is 165; the total number of stations is 455,000; the number of toll centers, 55. Some of the toll centers and tributaries will remain manual for several years after the target date.

As shown in Figure 1, Vancouver is the main switching center of the area both for intra-area and inter-area traffic, though, naturally, direct

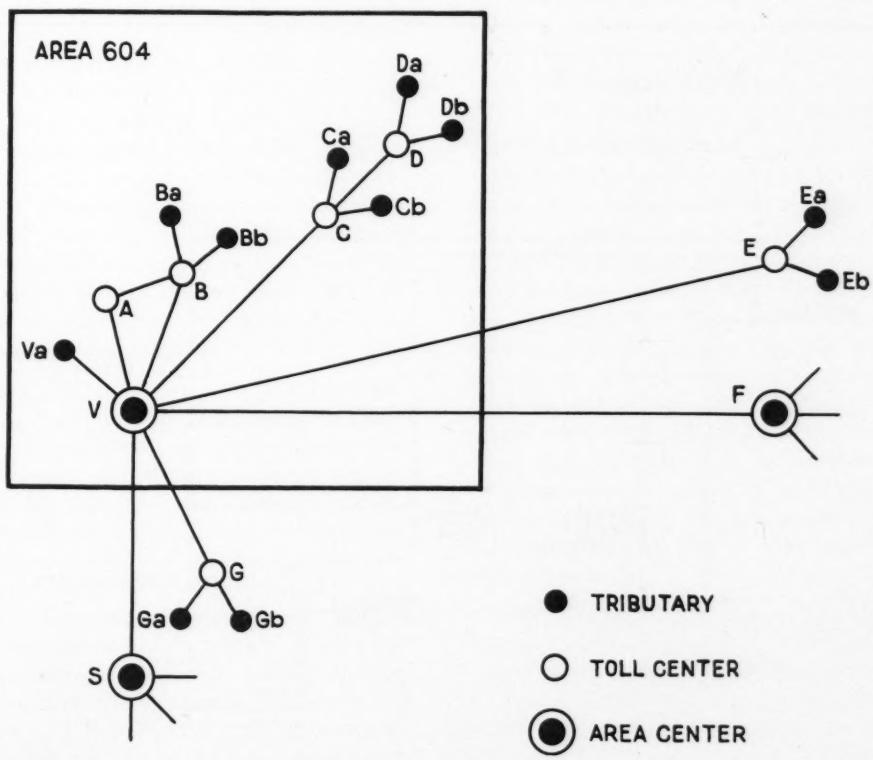


Figure 1. Basic Toll Routing Plan.

circuits exist between many of the other toll centers. Vancouver is connected by direct circuits to all but 20 toll centers, and while these 20 toll centers are at present reached through tandem points, some of them will be eliminated. There are direct circuit groups from Vancouver to five major and two other Canadian toll centers outside British Columbia. All traffic from Vancouver to the United States is switched through Seattle, with high usage groups also to Portland, Oregon, and to two smaller nearby toll centers. All local switching equipment in Canada is of the Strowger type or other step-by-step types, but two "4A" crossbar toll switching offices are planned for Montreal and Toronto.

There will be 60 toll circuit groups with about 800 circuits connected to the Vancouver toll switching center, and an automatic (cordless type) toll board of about 200 positions. The following summary gives the busy hour traffic volume, expressed in Traffic Units (TU), one TU being equal to 36 hundred-second unit calls.

Outgoing to Vancouver and tributaries	190TU	42%
Incoming to Vancouver	230TU	51%
Through switched to toll centers and tributaries	33TU	7%

The above data already shows the important fact that about 93% of the traffic is either originated by Vancouver operators or is terminated in the Vancouver local area; therefore any equipment layout should be so planned that it will provide maximum economy in the handling of this 93% share of the total traffic.

The outgoing traffic is split as follows:

Intra-area	128TU	67%
To United States	38TU	20%
To Canada	24TU	13%

The through switched traffic is split as follows:

From the Area	20.2TU	61%
From United States	4.6TU	14%
From Canada	8.2TU	25%

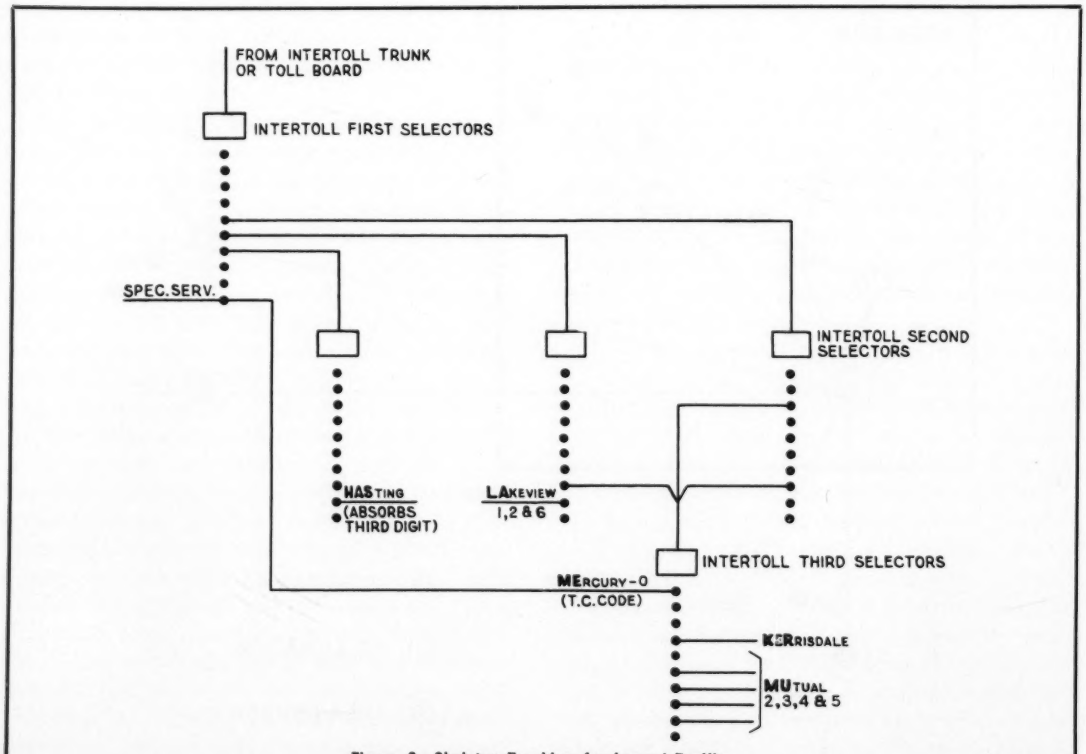


Figure 2. Skeleton Trunking for Inward Traffic.

Standard two-five numbers are being assigned to the stations of all central offices in the area. In Vancouver, during a transition period, mixed six-digit and seven-digit numbers will exist, each consisting of two letters and four or five numerals. For toll dialing purposes uniform seven-digit numbers are used; in six-digit offices the numerical equivalent of the third digit of the central office name provides the missing digit. Outside of Vancouver all newer offices are arranged for two-five numbering, while the ultimate central office codes are being assigned to older offices as well as manual offices. Such offices will be converted to standard two-five numbering as soon as practical.

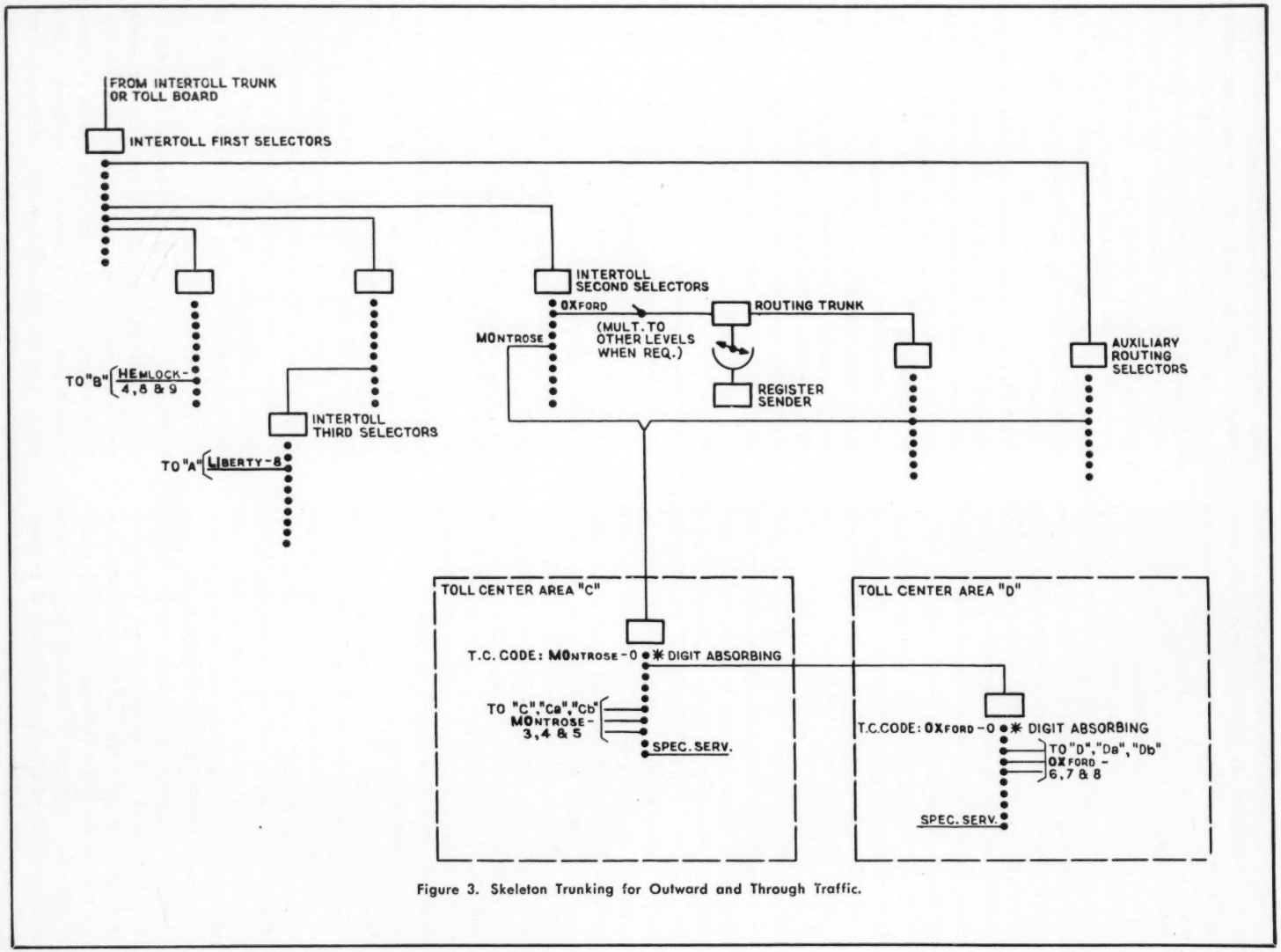
Let us consider first the incoming traffic to Vancouver local stations. Figure 2 shows a portion of the Strowger-type intertoll switch train. Trunks to single unit Vancouver offices are connected to intertoll third selector levels, and trunks to multi-unit offices are connected to intertoll second selector levels. Where separate trunk groups are provided from third selector levels to each unit, additional codes can be made available for other central offices. Trunks to central offices having six-digit station numbers for local dialing can be connected to the intertoll third selector level corresponding to the third letter of the office name, or to the second selector level, with the third digit absorbed in the toll switching trunk relay equipment. The latter practice is wasteful of central office codes due to nine other codes being made thus unavailable, and is recommended only in areas where a surplus of codes exists. However, where this practice is feasible, a rank of selectors can be eliminated.

Examining Figure 2, we note that any call, wherever it may originate, may be extended to any Vancouver station by the originating operator setting up a seven-digit directory number over the intertoll switch train and selector switches in the local office. If the call originates in any of the toll centers within the local numbering plan area, the operator reaches a trunk terminating in Vancouver and dials the seven-digit number for the direct control of the switch train in Vancouver. Calls from outside the local numbering plan area may go over direct trunks to Vancouver and the procedure is then the same as for intra-area calls; or if the call has to be switched at intermediate points outside the area, the area code 604 will direct the call to Vancouver, where the remaining seven digits will set up the switch train, as before. Vancouver toll operators may extend calls to local stations by dialing seven-digit numbers over the same switch train. Therefore one common switch train carries the traffic originating from all possible sources, and, as we shall see later, to all possible destinations. This results in maximum efficiency in the use of the switching equipment.

In Figure 2, four typical destinations in the Vancouver area are shown. Calls to Mutual numbers are carried through separate trunk groups from intertoll third selector levels to the units MU-2, MU-3, MU-4, and MU-5. Calls to Lakeview numbers are carried through a common trunk group from intertoll second selector level "52", and distributed by incoming selectors in the Lakeview office to units LA-1, LA-2, and LA-6. Calls to Hastings numbers are carried through a trunk group from intertoll second selector level "42", and the third letter "S" (or "7") is absorbed in the trunk relay group. Calls to Kerrisdale numbers (an office which is to be retained on a manual basis for some time) are carried through a trunk group from intertoll third selector level "537" with the subsequent digits displayed on call indicator positions.

Figure 2 also shows an artifice by which additional economies in switching equipment may be obtained. Where only a few levels are used in two or more third selector groups, and the codes used there are non-conflicting, (as in case of KERrisdale and MUtual 2, 3, 4, 5) such third selector groups may be combined in one; in this manner the number of selector groups is reduced and the efficiency per selector thereby increased. As new central office units are added, code conflicts may occur. Should this happen, the combination selector groups can, of course, be split up into their original constituents. In smaller offices even second selector groups can be combined by careful code assignment.

From the foregoing discussion it is clear that all incoming traffic terminating in the Vancouver area can be extended by use of listed directory numbers for the direct pulsing of Strowger selector switches, without any need for translation facilities or any other type of common control equipment, and with maximum economy and speed. By the time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MONTROSE
(MULT. TO OTHER LEVELS WHEN REQ.)
ROUTING TRUNK
REGISTER SENDER
AUXILIARY ROUTING SELECTORS
TO "B" HEMLOCK - 4, 8 & 9
INTERTOLL THIRD SELECTORS
TO "A" LIBERTY - 8
TOLL CENTER AREA "C"
T.C. CODE: MONTROSE - 0 ✱ DIGIT ABSORBING
TO "C", "Ca", "Cb" MONTROSE - 3, 4 & 5
SPEC. SERV.
TOLL CENTER AREA "D"
T.C. CODE: OXFORD - 0 ✱ DIGIT ABSORBING
TO "D", "Da", "Db" OXFORD - 6, 7 & 8
SPEC. SERV.

Figure 3. Skeleton Trunking for Outward and Through Traffic.

the last digit of the directory number is received, the called station terminal is reached and ringing current automatically sent out. As we have seen, such calls represent 87% of all inward and through switch traffic incoming to the intertoll switching center.

Next, let us consider the routing of calls to other points within the numbering plan area "604", but outside the Vancouver area. Figure 3 represents again a typical skeleton routing plan, the numbered locations corresponding to those shown in Figure 1.

The simplest cases are those represented by Vancouver tributaries, or toll centers without tributaries, such as "VA" and "A" in Figure 1. If the central office code of "A" is LIberty-8, calls to "A" are carried through trunks from intertoll third selector level "548". The last four digits of the seven-digit directory number set up the switch train in "A".

To toll center "B", two tributaries "Ba" and "Bb" are connected. The codes are HEmlock-4, HEmlock-8, HEmlock-9. Calls to these offices are carried through trunks from intertoll second selector level "43". The third digit operates the incoming intertoll selector in "B" and routes the call to "B" or "Ba" or "Bb", as the case might be. The final digits complete the call to the called station.

In the above cases the procedure is identical with that used in extending calls to Vancouver stations, i.e. Strowger selector switches are directly pulsed and calls completed without any delay through use of listed directory numbers only.

Calls to manual toll centers or tributaries require the dialing of three-digit routing codes which are identical with the central office codes to be used for the "2-5" numbering plan after the manual offices are converted to automatic operation.

There may be some cases where this simple trunking pattern will not suffice. For instance, in some multi-office areas, if the number of central office units and tributaries exceeds the capacity of a single two-digit code group, two or more code groups may be needed to take care of the area, though only a single group of toll trunks is to be used for all calls; or, calls to a toll center having its own tributaries, but not having direct trunks to Vancouver, may have to be switched through a tandem point, as shown in Figure 1 for toll center "D". In some numbering plan areas such complications can be avoided by careful planning; however, conditions may change as time goes on, and a really flexible intertoll switching system will meet such conditions.

The codes for toll center area "C" are MOntrose-3, MOntrose-4, and MOntrose-5. Calls are carried through intertoll second selector level "66", the procedure being identical with that of the "HEmlock" calls. In this example we are using second selector trunking; in other cases, however, third selector trunking can be employed without otherwise changing the general pattern.

The codes to toll center area "D" are OXford-6, OXford-7, and OXford-8. In this case, calls are carried through intertoll second selector level "66" to the MOntrose toll center, and thence over level "9" to toll center "D".

Let us first consider calls to area "D" originated by the Vancouver operator. While, as we shall see a little later, means are provided so that area "D" may be reached by use of the OXford codes only, the amount of such special routing means can be much reduced if the operator prefixes "0" to the OXford directory number. By following Figure 3 we can trace this path to the called terminal in area "D". The simple expedient of prefixing a "0" (or any other digit, or any two digits, for that matter) to a fraction of the outward calls, while not a necessary requirement of the system, introduces a worthwhile saving in the routing equipment.

Operator use of special routings is common practice today; however, with careful layout of the numbering plan such arbitrary routings can be largely eliminated in favor of use of the listed directory number, regardless of what type of equipment is used. However, there is a practical limit as to how far operators can get without additional guidance, this limit being set by circumstances beyond the control of the switching equipment. For instance, when a call is placed to a destination outside the numbering plan area, the operator must first ascertain the area code of the destination or any other routing to be used by the switching equipment available to her. She may have memorized the area codes or other directives of frequently used destinations, but others must be obtained from keyshelf bulletins and flip-flop

guides. As we have seen, 33% of the traffic originated in Vancouver terminates in other numbering plan areas, so this problem is not insignificant, but it is beyond the possibility of mechanization. An equally important reason for the operator to consult the routing guide is to find out if the called station is connected to a manual exchange, or can be reached by dialing. Now, of course, the operator memorizes a lot of this information with practice, and usually a relatively small number of destinations will include most of the traffic. The equipment arrangement described permits the operator to dial most of her intra-area calls by directory number, considerably reducing her burden. Whether the same should apply to all destinations, including those similar to area "D", must in each case be determined by its own merit; that is, we must ask whether the provision of automatic routing equipment is justified by the relief the operator gets, or whether the point of diminishing returns has been reached, bearing in mind that some routing work will inevitably remain which no amount of mechanization can eliminate.

Calls to area "D" from other toll centers of the numbering plan area can be extended in the same manner as described for the Vancouver operators. If we consider that only 13% of the incoming traffic to Vancouver is switched through, that only 61% of this originates within the numbering plan area, and that only a fraction of this requires special prefix codes, it becomes apparent that not more than 2% of the total incoming traffic could be so affected, even should the proportion of calls requiring special prefixes be as much as 25%.

When subscriber toll dialing is introduced within the numbering plan area, the toll ticketing equipment will include routing directives where such directives are required. However, with the arrangement now to be described much of the need for such directives can be eliminated.

Through switch calls from other numbering plan areas; i.e., from the United States and from other Canadian provinces, can be set up by the direct pulsing of the seven-digit directory number into the Strowger-type intertoll switch train, except in the case of such destinations as area "D". In such cases, operators in nearby toll centers and others having a high volume of traffic with British Columbia may receive the same routing directives as the Vancouver and other British Columbia operators; that is, to prefix "0" before the full directory number of area "D" stations. In other switching centers having a high volume of traffic with British Columbia, foreign area translation equipment may automatically furnish the routing directives to the operator-dialed or subscriber-dialed calls to toll center "D". However, it is probable that there will still be a certain amount of traffic to area "D" for which it will not be practical to distribute routing instructions to the many toll centers from which these calls might originate; nor will it be practical to provide automatic routing directives at all distant intertoll switching centers. Such residual traffic can be taken care of by the arrangement shown in Figure 3.

Any toll center, distant or nearby, within or outside of the numbering plan area, deliberately or contrary to instructions, may wish to reach toll center "D" by dialing, say, OXford-3. A group of so-called "routing" trunks are connected to level "69" of the intertoll second selectors. The purpose of these trunks is to seize a simple register-sender, and to indicate to the latter what routing digits are to be sent out. The routing trunks are very simples devices, consisting of a few relays only. Since the traffic they receive from a level is obviously very small, as shown in our previous discussion, each trunk group therefore should preferably serve several trunk routes similar to those serving area "D", and the proper routing directive can be given by the routing trunk to the register-sender corresponding to the level over which it was seized. This register-sender is the same as the one used for simplified automatic alternate routing, and which was mentioned in the previously quoted paper[3]. It receives and stores incoming dial pulses; but even before that, it sends out the routing digits ("69" in our example for calls to toll center "D") as prescribed by the routing trunk, which are then followed by the digits stored in the register-sender. A Strowger-type auxiliary routing selector is associated with each routing trunk, having those toll trunks connected to its various levels over which the calls received by the routing trunks are to be extended. For instance, the trunks to toll center "C" are connected to level "6" of the auxiliary routing selector, and calls to area "D" are first routed to these trunks over level "6" and then over level "9" of the incoming selector in toll center "C".

This is all that is required to provide toll dialing by the use of directory numbers throughout. Let us now consider the equipment needed in a fairly large intertoll switching center, such as Vancouver. To be on the most liberal side, we may specify that all through switch traffic, originating in British Columbia or at any other place outside, should be extended by the dialing of two-five directory numbers, and that only 75% of the traffic can be handled without additional digits, such as areas "A", "B", "C" or "Va", while 25% are of the type exemplified by area "D". The total through switch traffic is 33 TU, 25% of which is 8.25 TU. Two groups of routing trunks will handle such traffic, with 4.125 TU per group. At the grade of service 1 in 1000, each group requires 13 trunks, or 26 for the whole office, plus 26 auxiliary routing selectors. If register-senders are already provided for alternate routing purposes, one or two additional register-senders would be needed for the routing of these calls. The routing trunks have twenty relays each and a register-finder rotary switch. The intertoll selectors are standard Strowger switches with four relays and 660-point banks. However, it appears to be a more practical assumption that for all through switch traffic originating in the numbering plan area, and for half the traffic originating outside, the operators or other machines will do the routing, so that only 25% of 6.4 TU, that is 1.6 TU, will pass through routing trunks. The number of routing trunks and selectors can now be reduced to ten, and most likely no register-senders other than those used for alternate routing will be needed.

Let us review what has been achieved. All traffic incoming into or switched within a whole numbering plan area is extended by the dialing of the two-five directory numbers. All but 0.6% or, at the least, all but 3% of this traffic will be set up by straightforward pulsing methods on inexpensive direct pulse controlled Strowger selectors, and the rest of the traffic channeled through special routing equipment, which is negligibly small in view of the size of the installation. Actually, the inward and through traffic is only 58% of the total; therefore the fraction of specially routed traffic is only about half of the figures quoted above. Furthermore, it is axiomatic that the highest speed of service can be achieved only when the switch train is directly set up by the incoming pulses, while storage, translation and retransmission must necessarily introduce some delay. It is not only that costly and complex equipment, as needed in systems with 100% common control, is eliminated for 98% or more of the traffic, but also that the highest possible speed is retained for practically all the traffic. Because outpulsing commences from the routing trunks as soon as they are seized, there is no added delay on calls using these trunks. Furthermore, it is obvious that the routing trunks may be added, removed or rearranged where and when needed, with no interference with the rest of the equipment, and without affecting the operation of the system. Therefore the basic flexibility of the Strowger system is retained; in this case it is exemplified by the fact that common control equipment need be provided only when it does some good, and not because the system is inoperative without it.

Next the routing of calls to destinations outside the numbering plan area is to be considered. As we have seen, all such traffic will be extended through six principal outlets (five in Canada and one in the United States), and five other toll centers (two in Canada and three in the United States). Each of these eleven points is reached by the dialing of a two-digit prefix followed by a ten-digit or seven-digit directory number, or by any other special procedure required by the equipment at those distant points. These trunks are connected to vacant intertoll second selector levels, preferably "1" and "0". The use of such prefix codes can be considered as the automatic cordless toll board equivalent of plugging into the outgoing jack multiple of the trunk groups to those destinations on conventional cord-type toll boards, or the routing codes used in toll tandem practice.

Toll center codes may be assigned as needed. As previously mentioned, for smaller toll centers the central office code serves also as toll center code. In Vancouver, as shown in Figure 2, special operators and plant test facilities can be reached through a selector train connected to the first level of the intertoll first selectors, without any special toll center code. However, to accommodate toll switching equipment at distant control switching points, which requires distinct toll center codes, MErcury-0 may be considered in our example as the toll center code, and level "1" of the intertoll first selectors and level "630" of the intertoll third

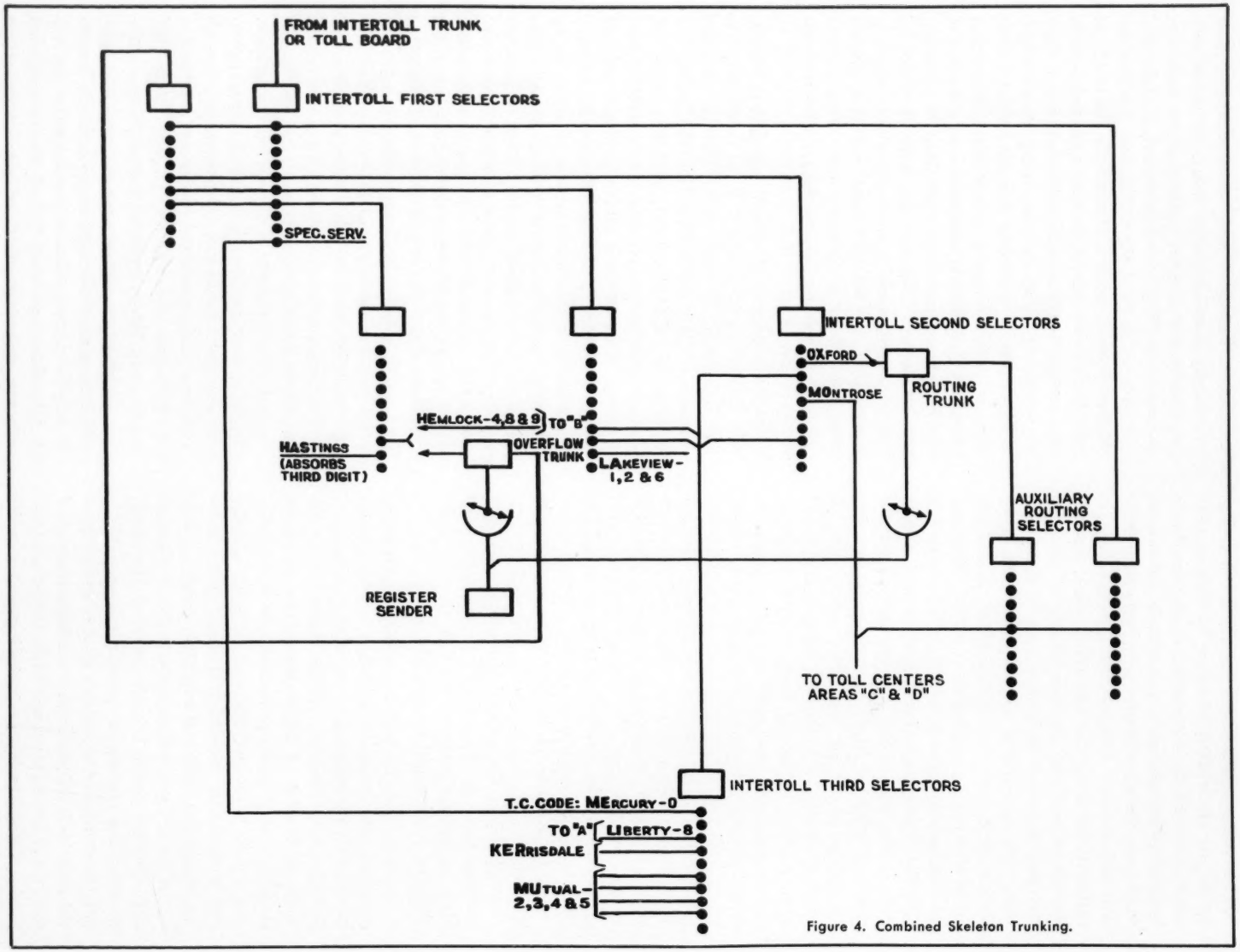


Figure 4. Combined Skeleton Trunking.

selectors are tied together for that purpose. MOntrose-0 and OXford-0 were assigned as toll center codes for "C" and "D", respectively, as seen in Figure 3. Special services in such places are usually reached via level "1" of the incoming intertoll selectors; however due to the digit absorbing feature on their "0" level, it is immaterial whether the third digit "0" is dialed or not.

The topography and other characteristics of toll centers in British Columbia limit the extent to which alternate routing of toll calls is feasible. By the visual display of group busy conditions to each of the Vancouver toll operators, the latter are readily able to handle the alternate routings themselves, in fact, as mentioned earlier in this paper, with a greater degree of flexibility than by any automatic means. There are various indications to guide the distant operator if congestion is encountered in the process of switching a through call, and simple automatic alternate routing equipment, already previously referred to[3], may be added where and when needed. Here again, through switch traffic is only 7% of the total, and only a fraction of this is over routes where alternate routing is feasible; therefore only the simplest automatic alternate routing equipment can be justified, if any at all.

Figure 4 combines the arrangements shown separately in Figures 2 and 3, as well as some of the additional provisions previously described. Of course, Figure 4 represents only a fraction of the intertoll switch train at Vancouver, and is shown here only as a typical example of the general principles we have discussed.

The author had the opportunity for a number of years to be actively engaged in planning several large toll dialing areas to be integrated in the continental network. He found that by a kind of building-block technique, with step-by-step equipment, due to its flexibility, the most economical as well as the most suitable arrangement can be assembled for each particular application. Every one of these cases was different from the others, and, furthermore, conditions and requirements are changing all the time. Many of these conditions and requirements are unforeseeable between the time when the equipment is initially planned and the time when it is placed in service. Usually during the initial service period the conditions are relatively straightforward, and with the technique described in this paper the initial investment is at a minimum, yet the system provides the highest speed of operation. As time passes, new and previously unpredictable conditions arise. Equipment specially designed to take care of these conditions can be added, but because usually only a fraction of the traffic is affected, the added equipment is concentrated only at those points where it is actually needed, which is obviously also a sound economic policy.

The same principles were embodied in the "FW-1" Intertoll Switching System recently developed by Automatic Electric Company for continent-wide toll dialing, described in this paper, as well as in the Company's four Automatic Toll Ticketing systems. The features of the "FW-1" Intertoll Switching System include four-wire switching of transmission paths throughout; pad switching; pulsing and supervisory signals completely separated from the transmission paths; silver-inlaid bank contacts; integrated high speed automatic cordless toll board with a new, efficient method of automatic call distribution and new, inexpensive keysenders; automatic alternate routing and code conversion, as discussed in this paper. It can be planned without any common control, or with partial common control. or with full common control, whether introduced initially or added at any time later and at any point; automatic camping or other disposition of calls under delay and overflow conditions; a new method of centralized automatic traffic recording of the whole system; centralized control and supervision of traffic operation; high efficiency service observation; plant test facilities; self-contained power and supervisory equipment; and others. The equipment for the first application of this system is being manufactured for New Westminster, B. C., and is to be placed in service in 1955.

References:

1—Transmission Design of Intertoll Telephone Trunks. H. R. Huntley. *Transactions AIEE* Vol. 72, Part 1, 1953, pp. 670-676.

2—Traffic Engineering Techniques for Determining Trunk Requirements in Alternate Routing Trunk Networks. C. J. Truitt. *The Bell System Technical Journal,* March, 1954, pp. 277-302.

3—Common Control and the Strowger System. C. F. Ffolliott. *The Automatic Electric Technical Journal,* Vol. 3, No. 4, March, 1954.

THE FIRST DECADE OF SATT SYSTEM OPERATION

By J. E. OSTLINE
Project Engineer, Automatic Electric Company

SYNOPSIS: *Economies and service improvements from SATT operation—reasons for new developments — changes in Type B system—the Type D system—the SATT transender—the detrel detector—a look into the future.*

INTRODUCTION

THE SATT (Strowger Automatic Toll Ticketing) system entered upon its second decade of operation in 1954. The experience gained and the results achieved during the preceding ten years by plant, operating, and commercial departments of telephone administrations now providing SATT service, both in the United States and abroad, clearly demonstrate two basic facts. One is that SATT operation introduces definite economies in all functions involved in providing station-to-station toll service in automatic exchanges and toll networks, and paves the way for similar economies in subsequent billing and accounting functions. The other is that, to subscribers, SATT operation is the most satisfactory method so far devised of obtaining this class of service. We may justly assume from these two facts that SATT operation, which represents the Automatic Electric method of handling "customer toll dialing", is here to stay.

During the past ten years, the Automatic Electric Laboratories have steadily introduced improvements in SATT system arrangements, and have developed new types of equipment, new circuits, and new operating techniques. These changes have been brought about as a result of constant study of various aspects of the whole problem, including: (a) the operating experience obtained from existing SATT system installations, both here and abroad; (b) the new equipment, circuit, and operating techniques devised for use in automatic local and toll switching operations; (c) the steadily increasing amount of new information available on developments and operating requirements for long-haul ("foreign area") customer toll dialing (FACD); and (d) the various mechanical accounting methods and equipment which are now available from several manufacturers, and which take up mechanization of accounting and billing where SATT operation leaves off.

This article is intended to describe in outline some of the more recent developments in SATT equipment and system arrangements which have resulted from the foregoing studies. Since it covers recent developments rather than basic principles some of the details given in earlier treatises on SATT systems may be needed as prerequisites for full understanding, and for this purpose the reader is referred to two former papers by the same author.[1]

In addition, before entering into a discussion of new SATT systems or recent changes in existing systems, it might be helpful to summarize the main features of the four basic types, particularly as they relate to the operations of the calling subscriber:

Type A is a Director-equipped system primarily for use in metropolitan areas. To make a short-haul toll call, the subscriber dials only the directory number of the called station. His call is automatically directed over a preferred or alternate route; and the number of the calling line—or calling station on a party line—is automatically identified and recorded by the ticketing equipment.

1. The Expanding Field of Application for Strowger Automatic Toll Ticketing. J. E. Ostline. *The Automatic Electric Technical Journal,* July, 1951.

   Automatic Call Recording and Accounting in the SATT System. J. E. Ostline. *The Automatic Electric Technical Journal,* May, 1953.

FIRST TOLL TICKET AUTOMATICALLY PRODUCED BY AN INDEPENDENT TELEPHONE COMPANY

Shown below is a replica of the first toll ticket produced in the United States without the assistance of an operator on a commercial call originating in an Independent telephone exchange. This ticket was produced as the result of a business call on April 13th, 1944, at 9:21 A.M. by Mr. C. F. Mason, President, Associated Telephone Company, Ltd. at Santa Monica, California, to Mr. George Jones of Mitchum Tully Company, Los Angeles, MAdison 2621.

The replica of the toll ticket shown below was produced by the Automatic Toll Ticketing System designed, manufactured and installed at Santa Monica, California by Automatic Electric Company, Chicago, for the exclusive use of Company officials as a means of determining problems which might be confronted when direct customer dialing of toll calls within the Los Angeles Metropolitan Area is made available to the general public.

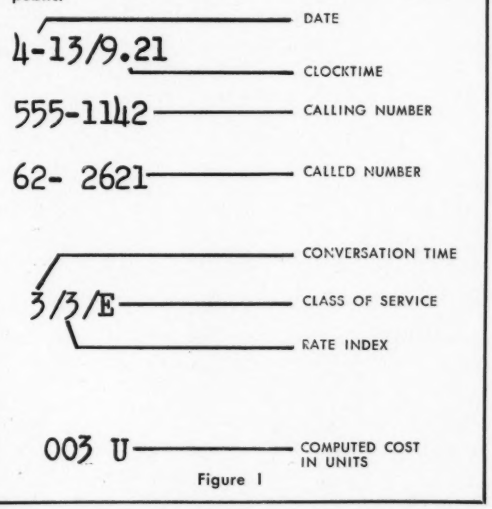


Figure 1

Type B is similar in subscriber operation to Type A, except that the calling subscriber must dial a SATT access code in advance of the called number. As with Type A, the number of the calling line or calling station is automatically identified and recorded.

Type C also requires the calling subscriber to dial a SATT access code, but in addition he dials his own number, immediately before dialing the number of the called station. Automatic verification of the calling line number is provided.

Type D requires the calling subscriber to dial the SATT access code and the number of the called station. Before completion of the connection, an operator is connected into the line, and she asks for the number of the calling station, and then key-records that number into the ticketer. The talking path is then automatically completed.

NEW SATT SYSTEM DEVELOPMENTS (1954)

Customer National Toll Dialing

The Independent operating field is by this time generally familiar with the Bell System's introduction during recent years of "FACD" (foreign area customer dialing). The ultimate purpose of this plan is to enable any automatic telephone subscriber in any exchange provided with suitable automatic toll ticketing facilities to dial station-to-station toll calls to any point anywhere within the United States and parts of Canada.

The general plan for the participation of Independent telephone companies in this nationwide service has been established, and a committee representing both the Independent companies and the Bell System is now engaged in regular discussions and coming to agreement on various details as the need arises.

The Automatic Electric Laboratories several years ago anticipated this expansion of short-haul SATT systems to fit into the nationwide long-haul subscriber dialing network. As a result, all types of SATT system installations are now designed and installed in such a manner as to permit such expansion, without the need for removals or alterations in initial installations, but merely by adding the required types and amounts of long-haul equipment to an initial short-haul installation. The additional long-haul equipment consists primarily of *"transenders"* in various arrangements, the transender being a new SATT system component which is described later in this article.

New SATT System Types

The Type B System

This system was originally designed to be "direct dial controlled". However, field studies have indicated that in many existing exchange areas, as well as in new areas for which this system would normally be specified, conditions will often exist wherein "common control" operation will produce economies in both outside plant and in switching equipment. Consideration should also be given to the important factor that exchange areas of this general type will often be among the first to obtain access to the national customer toll dialing network.

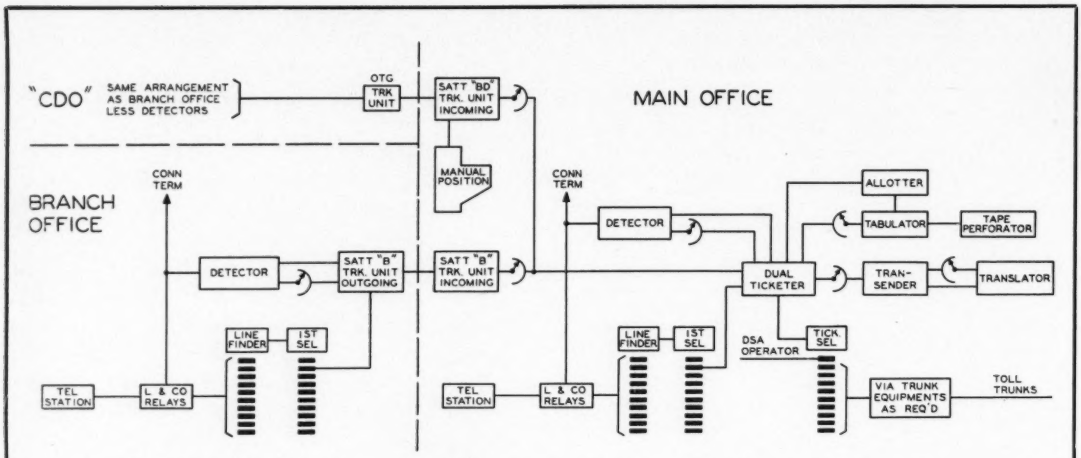


Figure 2—Block diagram of Type B SATT System, for multi-office area, with complete "B" service for branch offices and "BD" service for C-A-X or CDO offices. (Note: Toll access code is "90").

As a result of the foregoing conclusions, the Type B system has now been changed to common control operation by the introduction of the *transender*. Thus in this system, the switching process for all customer dialed short-haul as well as long-haul toll calls is now similar to that in a Director-controlled Type A SATT system. So far as subscriber operation is concerned, the only difference lies in the fact that in a Type B system, the subscriber has to prefix all station-to-station toll calls with a SATT access code. This is not required in a Type A system.

The reason for the SATT access code is that in a Type A system a Director is associated with every call initiated, whether local or toll, whereas in a Type B system local calls will always be direct dial controlled. To bring the common control equipment into play on toll calls, the subscriber dials the access code.

For exchange networks using the Type B system, a new dual type ticketer is also available. This dual type ticketer, installed in a main office, is used for the processing of subscriber dialed toll calls from that office as well as from stations served by branch offices. This eliminates the need for ticketers, tabulators, and tape recorders in each smaller branch office, and concentrates records of calls from such offices at a central point.

Full automatic detection (identification) of calling station numbers in both main and branch offices and the recording of such numbers in the main exchange ticketer are provided. The *"detrel"* detector provided for this purpose is discussed later under that heading. The block diagram of Figure 2 shows a typical Type B SATT system arrangement for a multi-office exchange area.

Another new facility now available with the Type B system is what is known as *Type BD* SATT service. Exchange networks of the kind to which the Type B system is adaptable often include small automatic offices (variously called C-A-X's or CDO's) in which the installation of Type B branch office equipment would not be economical. In such offices Type BD SATT service can be provided at comparatively low cost.

As the designation indicates, with this arrangement a C-A-X or CDO subscriber can be provided with Type D system facilities via the Type B SATT equipment in the main office. No special equipment is required in the originating office, and a Type BD calling station dials station-to-station toll calls in exactly the same manner as a station in an office equipped for Type B service. The added equipment needed in a main office to provide this service consists of SATT BD trunk units and the regular Type D manual facilities.

The Type D System

This is a new SATT system arrangement which has been designed for exchange networks contain-

ing a number of small dial offices connected to a common attended office for toll and special services. Where these manual facilities continue to be available, the Type D system can provide customer toll dialing for subscribers connected to the various dial offices of such a network at a comparatively low cost. In operation this system is somewhat similar to the Type C system except that a Type D system subscriber, when making a toll call, need not dial the number of his calling station.

Ticketers for a group of dial offices of this type are usually concentrated at a common point—generally in the office where the manual switchboard is located. No special trunks, trunking equipment, or calling number verifiers are required in the various automatic offices; therefore existing trunking facilities can be used without added equipment.

In the Type D system, an automatic station subscriber, when desiring a station-to-station toll connection, dials the following items:

(a) A SATT access code of two or three digits; and

(b) The directory number (and special prefixes if so indicated in the directory) of the desired station.

After the SATT access code has been dialed, the call is extended to a ticketer in the main office. This ticketer immediately calls for, and is connected to, a free transender from a common group. When the called station number is dialed, it is stored in the ticketer.

If the called station is located in a step-by-step automatic exchange, all digits of the dialed number except the last two will be re-transmitted by the transender into the called exchange. As soon as the last digit of the called station has been dialed, a connection is automatically extended from the ticketer to a SATT control equipment at the manual board, via a key or jack ended trunk. The control consists of a key type pulse sender common to the manual position.

An operator now enters the connection and verbally obtains from the calling subscriber the number of the calling station; she then keys that number back into the ticketer where it is stored. The operator then, by means of a release key, releases the trunk from the ticketer. As soon as the foregoing operation has been completed, the transender transmits the last two digits of the called number from the ticketer storage, and releases itself from the ticketer. The toll connection is now completed via the ticketer, and from this point on all functions are similar to those on a call in any type of SATT system.

A call from a Type D system may terminate in a panel or crossbar office. In such a case, the entire called number will be held in the ticketer by the transender until the operator has obtained and recorded the calling station number as previously described. At the end of this recording, the transender starts the transmission (pulsing out) of the called number. When this is finished, the talking path between the calling and called stations is completed via the ticketer, and the transender is released.

After the operator has started the key-recording of the calling station number, and during the transmission of all or the last two digits of the stored called number, the calling subscriber will hear a "progress" tone—a tone which is distinct from other standard tones used in automatic switching. The purpose of this tone is to caution the calling subscriber not to release a connection because of the absence of an expected ringing tone; the latter will be heard after pulse transmission from the transender is completed.

If it is desired to verify the calling number given verbally by the calling subscriber, the operator can do so in the same manner and by the same means provided in the case of manually handled toll calls.

Transenders for Type D SATT systems are normally of the re-send type; that is, regenerated pulses for each dialed digit are re-sent in their original values. However, when translations are required for trunk routing or other purposes, a translator common to a group of transenders can be added without any change in an original installation.

The block diagram of Figure 3 shows a typical Type D SATT system arrangement for a multi-exchange area.

The SATT Transender

The transender is a new unit similar in function to a Director. However, where a Director has to

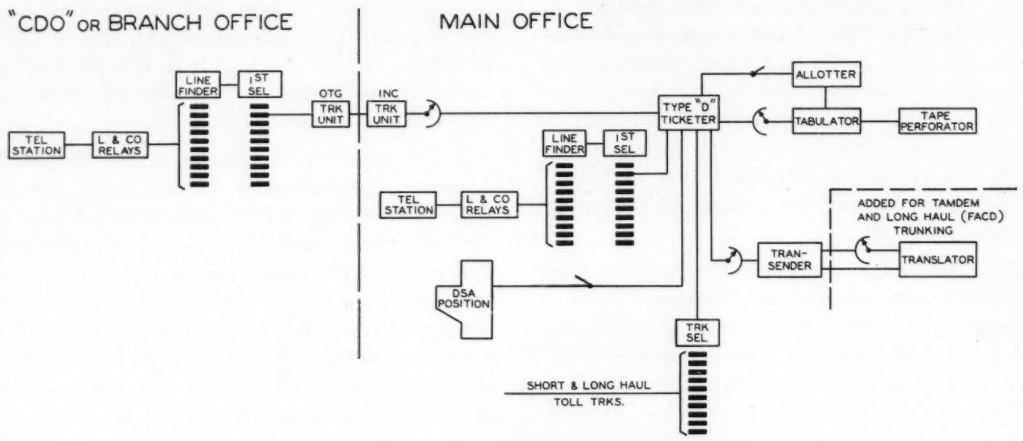


Figure 3. Block Diagram of Type D SATT System, for multi-office areas.

be arranged for all types of calls which may originate in an exchange, the transender is arranged to process only subscriber-dialed toll calls.

A *complete* transender installation consists of transenders, and a translator common to all transenders. The translator is of the same type as that used with the Director. In this form, the transender provides "single code" translations from an exchange or area code, or "dual code" translations from both. These two varieties of code translations are sometimes referred to as "three-digit" and "six-digit" translations.

The transender is also provided in a *partial* form for those operating conditions where no translations are required, but where subscriber dial pulses require regeneration and repeating.

Translating transenders are always provided for the Type B SATT system. Partial (pulse regenerating) transenders are normally provided with the Type D system. They are also normally provided with the Type C system except where the telephone company desires to omit them. However, Type C installations are always arranged so that transenders can be added at any time after the initial installation; and this will always be the case when a Type C installation is arranged for expansion into the national long-haul network (FACD).

The Detrel Detector

In the redesign of the Type B SATT system, it became apparent that many new automatic exchange installations are now being arranged to provide for party station service on a "terminal per station" and "frequency per *terminal*" basis. Also, due to the rapid expansion of large population areas, eight-station and ten-station service is coming into widespread use.

The present SATT system detector is arranged to handle a maximum of five stations per line on a "terminal per station" and "frequency per *group*" basis. It was therefore decided to design a new detector which is now referred to as the *detrel* type. This unit will replace the present type of detector on all future SATT installations of Types A and B. It provides automatic terminal number detection on individual line stations and on party line stations up to ten per line.

The recent developments described above, as well as other improvements of a less consequential character, have served to confirm once again the basic flexibility of Strowger SATT equipment, and offer assurance to telephone companies that no matter how the plans and procedures for nationwide customer toll dialing may develop in future years, SATT operation will prove capable of ready adaptation to the new conditions.

APPLICATION OF PUNCH CARD ACCOUNTING TO STROWGER AUTOMATIC TOLL TICKETING

By ALLAN R. STACEY
Vice President and Manager, Sunland-Tujunga Telephone Company

SYNOPSIS: *Varieties of toll calls—selection of billing method—evaluation of Sunland-Tujunga accounting system—economics of accounting selection—work flow and control—programmed improvements—growth potential — punch card service bureaus—what lies ahead.*

Introduction

The purpose of this article is to demonstrate the merits of mechanizing billing procedures when telephone central office equipment is being mechanized by the installation of automatic toll ticketing equipment.

More and more telephone companies are installing equipment for subscriber dialing of toll calls. These companies have recognized that high mechanization of the telephone toll traffic which requires ticketing provides the telephone user with maximum speed and fewer operator contacts and at the same time results in reducing annual costs to a minimum. The telephone industry has an equal opportunity to make savings by mechanizing the billing procedures that are coordinated with subscriber dialing.

To obtain full efficiency and economy a mechanized billing system should accomplish the following with minimum assistance from human hands and human minds:

1. Sort the ticket or record of the call for billing purposes.

2. List the individual telephone calls by date, called number and toll charges on individual subscriber statements.

3. Total up the long distance charges on the toll statement.

4. Establish accounting controls for the summation and verifying of all customer toll statements for each billing period.

5. Total up and list the exchange service charge, previous balance, directory advertising and any other charges which may be applicable to the account.

6. Establish accounting controls for all subscriber accounts receivable for verifying payment and pursuing delinquent accounts.

With these objectives in mind, the Sunland-Tujunga Telephone Company of Los Angeles, California, began placing into service in 1949 units of International Business Machines Corporation punch card equipment. These units were installed to process the subscriber billing and were programmed for ultimate coordination with Strowger Automatic Toll Ticketing Equipment to be placed into service in 1950. This coordination was accomplished in January, 1950, and the punch card equipment proved to be a natural complement to subscriber toll dialing by introducing into subscriber billing practices the maximum efficiencies available in automatic toll ticketing.

The programmed installation of punch card equipment occurred in two stages. Initially only a manual key punch was placed on the Sunland office premises and up until January of 1950 it was used to prepare *basic* data (such as *total* toll charges for a subscriber for the billing month) and the cards were taken to a nearby IBM service bureau for further processing which produced the subscriber's bill. Under this method, which might be called semi-automatic, the toll statement was manually typewritten and only a summary card for total toll calls was key punched. In 1950 all the punch card equipment necessary for full revenue accounting production was placed on

Table I

COMPARATIVE DATA ON REVENUE ACCOUNTING DEPARTMENT

On Manual Basis, Semi-Automatic Basis, Full-Automatic Basis

1947- 1954

	1947 Manual Basis	1949 Semi-Automatic Basis	1954 Full-Automatic Basis	% Increase or (Decrease) 1950-1954
Number of Customer Accounts Billed	3,400	4,800	7,200	50%
Number of Billing Rounds Per Month	1	1	1	
Type of Billing Machines	Typewriters & Adding Machines	Typewriters, Adding Machines, & IBM Service Bureau	IBM Punch Card Machines	
Number of Employees	6	6.5	3	(46%)
Square Feet of Floor Space	300	410	588	43%

Sunland premises; this has been termed the fully automatic period.

Mr. John T. Naylor, now Vice President and General Manager of Philippine Long Distance Telephone Company, was at that time Vice President and Manager of the Sunland-Tujunga Telephone Company. Mr. Naylor wrote a comprehensive description on the Sunland installation entitled "Application of Strowger Automatic Toll Ticketing and Punch Card Toll Accounting in Metropolitan Telephone Networks". His accurate and exhaustive analysis was published in *The Automatic Electric Technical Journal* in February 1950 and quotations and references will follow in this article.

The economies inherent in punch card mechanized billing are shown in Table I, which draws a quick comparison between the manual system in use by the Sunland Company in 1947, the semi-mechanized system being used in 1949 and the fully automatic system cut into service in 1950 and still not at its maximum capacity in 1954. It will be noted that in 1947 on the manual basis the company was using six employees to bill 3,400 accounts in one billing round and that in 1954 three employees were billing 7,200 accounts in one billing round. Later sections of this article will discuss the cost savings inherent in punch card mechanization.

It should be recognized that the manual system used by the Sunland Company prior to 1948 had as its basic tools manual typewriters and electric adding machines. In recent years other types of equipment and cost savings techniques have been adopted by the telephone industry. These include the use of electric typewriters, specialized toll billing machines and the adoption of microfilm techniques. The fundamental difference between these improved methods and the punch card equipment coordinated with Strowger Automatic Toll Ticketing lies in the fact that each of the other methods, although modernized, continues to rely on the processing of a *printed* ticket which requires sorting by the human hand and interpreting by the human eye. The attendant human errors and

Table II

TOLL TICKET DISTRIBUTION

June 1954

(a) Class of Tickets	(b) Automatic Tape Prepared Tickets	(c) Operator Prepared Tickets	(d) Not Billed, Memo Tickets
Los Angeles Metropolitan Area "Station" ("Message Unit" calls)	87,858		
AB "Station" ("DSA" Board calls)		2,357	
Inter-exchange Receiving Service (Billed to called party)		532	
AB Coin Box			7,574
Incoming "collect" from Metropolitan Area		639	
Outgoing "person" to Metropolitan Area		154	
Long Distance		4,263	
Totals	87,858	7,945	7,574
% of Total Tickets	85%	8%	7%
% of Total Tickets Requiring Detail Billing	92%	8%	

delays are eliminated by coordinated punch card and subscriber dialing equipment in favor of mechanized speed and precision because this method begins with the data imposed upon a punched tape which in turn produces a punched card available for mechanical sorting at extremely high speed and mechanical summarizing of charges and printing of information at exceedingly rapid rates.

Toll Ticket Characteristics and Volumes

The distribution of the Sunland Company toll tickets is shown in Table II. Column (b) shows that 87,858 tickets (85% of the total) were subscriber dialed through Strowger Automatic Toll Ticketing with a punched tape record being made on each completed call. The calls requiring operator handling total 7,945 (or 8%) from residential and business telephones, and 7,574 (or 7%) were from coin box locations.

It is of material significance that 92% of the total billable traffic was handled through subscriber dialing equipment which prepared an initial tape record of the call. At the option of the telephone company this punched tape will produce either a printed ticket or a punched card. Using the tape to prepare a printed ticket reasonably uniform with the standard toll ticket known today will permit the billing department to merge the subscriber dialed tickets readily with the operator prepared

tickets and continue present billing procedures relatively unchanged. However, and this is the unique and economy feature, the punched tape will also produce a punched card for each call handled by the toll ticketing equipment. Capitalizing upon this feature is the key to savings in the billing department at Sunland.

Selection of Billing Method

In selecting a billing method the basic objective was to provide the customer with the most detail and to cause the telephone company the least cost. While these two objectives may appear to be at opposite poles it actually proved possible to coordinate the two in the Sunland installation, a medium size company.

As stated by Mr. Naylor, "Significant factors influencing the selection of method for the interpretation and ultimate billing of toll charges are (1) previously established methods of billing for a given company, (2) the degree to which uniformity of billing methods is to be sought, (3) relative quantity of toll tickets produced in the *subscriber* dialing range as against toll tickets produced in the *operator* dialing range, (4) the availability and arrangement of floor space for revenue accounting and for filing, and (5) the proximity and efficiency of service of available accounting methods firms capable of supplying and servicing billing machines. The final determination of the appropriate choice in the light of all of the foregoing factors is necessarily established by the economics of available alternatives."[1]

Previously established billing methods—At the Sunland office it was possible to discontinue entirely the previously established manual system of billing because of the nominal investment in office equipment, furniture and other tools that would not be usable either in other departments or for billing under the mechanized procedures.

Uniformity of billing methods—Upon conversion to automatic billing the Sunland office was able largely to continue its previously established forms and detail provided to the subscriber without increasing billing costs. Thus, the revision of billing equipment required little public education for acceptance of a new form of bill or toll statement.

Quantity of toll tickets produced in the subscriber dialing range—With the introduction of automatic toll ticketing the Sunland office had a highly favorable ratio of toll tickets produced in the subscriber dialing range compared to those produced in the operator dialing range.

Floor space cost—It was true in the Sunland installation and will probably hold for most cost comparisons in similar localities that the cost of floor space occupancy and the usage of incidental materials such as stationery items will not vary consistently or to any significant degree when manual billing methods are contrasted with punch card methods. However, it is necessary to give additional weight to the cost of punch cards themselves and to filing and storage space for punch cards. These two items were included as an additional cost in studying Sunland's alternatives and should so be included by any company contemplating a conversion because they usually constitute an additional cost to the billing department over and above other methods.

Proximity of machine repair servicemen—The Sunland office is located approximately 20 miles from the Los Angeles central business district. As a result efficient and capable organizations to service the billing machines were readily available.

At the time that the installation of Strowger Automatic Toll Ticketing was being programmed, the Sunland Company had to decide between obtaining a printed toll ticket or a tape which could be used to produce a punched card as the record of each call. At that time comparative annual costs were developed which showed an anticipated total charge of $16,080 for use of the printed ticket method compared with $12,080 for use of the punch card ticket method.[2] It was apparent, therefore, that the punch ticket method produced initial savings and time has demonstrated that there are even greater savings in the capacity of the punch ticket method to handle ever increasing volumes with minimum additional expense.

1. Application of Strowger Automatic Toll Ticketing and Punch Card Toll Accounting in Metropolitan Telephone Networks. J. T. Naylor. *The Automatic Electric Technical Journal*, February, 1950.

2. *Ibid.*, Page 69.

Table III

NUMBER OF MECHANICAL ERRORS ON AUTOMATIC TAPE PREPARED TICKETS

1953

Annual Total Automatic Tape Prepared Tickets	994,188
Tickets In Error	293
Incorrect Tickets Per 1,000 Prepared	0.29

Note: These mechanical errors may be compared to number transpositions, illegible writing and incomplete recording by switchboard operator on operator-prepared tickets.

Performance and Economics of Sunland-Tujunga Accounting System

After two years of operation on a semi-automatic (service bureau) basis and four years of operation on a fully automatic basis it is the consensus of the Sunland Company that punch card billing has produced more accuracy, more capacity for volume, more reliability than any other available system and all at less cost than could have been accomplished otherwise.

More accuracy—Greater accuracy was evidenced by reduction in (1) the number of operator transpositions and incomplete tickets, (2) the number of toll charges challenged by the customer as the charges appeared on the toll statement, (3) the number of errors in toll billing as a result of billing tolls to the incorrect originating telephone and (4) the number of instances in which the toll statement lists had been incorrectly added to total.

In the previous manual system a certain quantity of tickets received from the traffic department was not billable because of number transpositions,

Table IV

ANNUAL RATIO OF ERRORS TO TOTAL TOLL TICKETS BILLED

1954

1954	Number of Toll Tickets Billed	Number of Errors on Billing
April	89,113	9
May	87,276	6
June	95,271	14
Total	271,660	29
Annual (above total X 4)	1,086,640	116
Errors Per 1,000 Tickets Billed		0.11*

*Approximately one error in ten thousand tickets billed.

Table V

COMPARISON OF BILLED TICKETS CHALLENGED BY SUBSCRIBERS

Manual Billing vs. Mechanized Billing

Year	Annualized Tickets Billed	Number of Tickets Challenged	Challenged Tickets Per Thousand Billed
1949 — Local Dial Service, Operator AB Toll and Operator Long Distance, with Manual Typing of Toll Statement	825,300	6,360	7.71
1954 — Local Dial Service, Automatic Ticketing AB Toll, Operator Long Distance, with Fully Mechanized Billing	1,086,640	1,012	0.93

or incomplete information on the ticket, or the fact that the information recorded was illegible. Introduction of automatic tape preparation of tickets reduced the quantity of this type of error to 0.29 per thousand tickets prepared. Table III shows that during 1953 the automatic tape prepared tickets totaled 994,188 with only 293 of these being unsuitable for billing.

As the 293 tickets improper for billing were detected prior to processing of the data into the billing procedure the remaining tickets were without transposition of number or other error on all of the automatic tape prepared tickets. This caused 92% of the total billable tickets to be without error at the source. Since punch card equipment will produce accurate results at the end when supplied with accurate data at the beginning, it becomes apparent that errors in billable tickets would appear only in the remaining 8% of the total volume. Table IV shows that on an annual basis the number of errors in toll billing amounted to 0.11 per thousand tickets billed.

The immediate result of the reduction in errors in billing was a decrease in the number of individual toll calls challenged by the subscriber as improperly listed on his toll statement. Table V shows that during 1949 when the Sunland office was on a local dial, operator toll basis (toll statements were being manually typewritten) the number of tickets challenged per thousand tickets billed was 7.71. During 1954 when the Sunland office was on a local dial service basis, an automatic ticketing basis for short haul toll, and an operator toll dialing basis on long distance the number of tickets challenged by the subscriber amounted to 0.93 per thousand tickets billed. Of these 0.93 per thousand challenged, Table IV has already shown that 0.11 per thousand were in error.

The development and maintenance of adequate accounting controls to insure accuracy of the billing job is readily possible with punch card equipment. As a result of quality equipment and adequate controls the Sunland office in four years of operation, 1950-1954, has never had an incorrectly added toll statement returned by a customer.

More capacity for volume—Reference to Table I will disclose that the backbone punch card system initially installed had capacity for large growth as well as being an immediate improvement over the previous manual system. The manual system required six people and 300 square feet of floor space to bill 3,400 accounts in one round. The punch card system necessitated 6.5 employees to bill 4,800 accounts on a semi-automatic basis and dropped to three employees upon conversion to full automatic production in 1950. In addition, the full automatic billing was able to increase its capacity to bill 7,200 accounts in 1954 without

Table VI

ANNUAL CHARGES FOR PUNCH CARD BILLING DEPARTMENT

1954

Annual Payroll one supervisor and two machine attendants			$11,516.00
Taxes and Fringe Benefits @ 8%			921.00
			$12,437.00
Rental of IBM Punch Card Equipment			
1—026	Printing Card Punch	$ 690.00	
1—077	Collator	960.00	
1—082	Electronic Sorter	720.00	
1—405	Alpha Accounting Machine	4,200.00	
1—517	Gang Summary Punch	840.00	
1—797	Automatic Key Punch	720.00	
1—921	Automatic Carriage	240.00	
		8,370.00	
	Excise Tax @ 10%	837.00	
			$ 9,207.00
Fixed Charges on $4700 investment in files, desks and miscellaneous equipment for punch card operation			
	Depreciation @	7.0%	
	Property Taxes @	2.8%	
	Maintenance & Insurance @	2.0%	
	Interest & Earnings	7.0%	
Total $4700 Investment @		18.8%	884.00
Total Annual Charges to bill 7,200 accounts per month on Punch Card Basis			$22,528.00

Note: As station growth occurs, revenue accounting department will bill 27% more subscribers (up to 9,200 accounts) without additional employees or punch card equipment. This will reduce cost per bill from $0.26 to $0.20.

additional personnel and with a modest increase in floor space. It is estimated that the punch card equipment has a remaining capacity of billing up to 9,200 accounts without change of personnel or equipment.

More reliability—At the Sunland office the introduction of punch card equipment provided a greater sense of reliability, a feeling that work schedules could be met and billing rendered on time without undue strain. The equipment leveled peak loads and eliminated any necessity for premium overtime to complete the bills by a deadline. An intangible asset proved to be the fact that the punch card machines were not subject to vacations, sick time, social security and unemployment taxes, pension plans and leaves of absence. Obtaining competent help to operate punch card equipment proved to be no problem.

Less cost—Table VI shows that 1954 annual charges for the Sunland office billing department

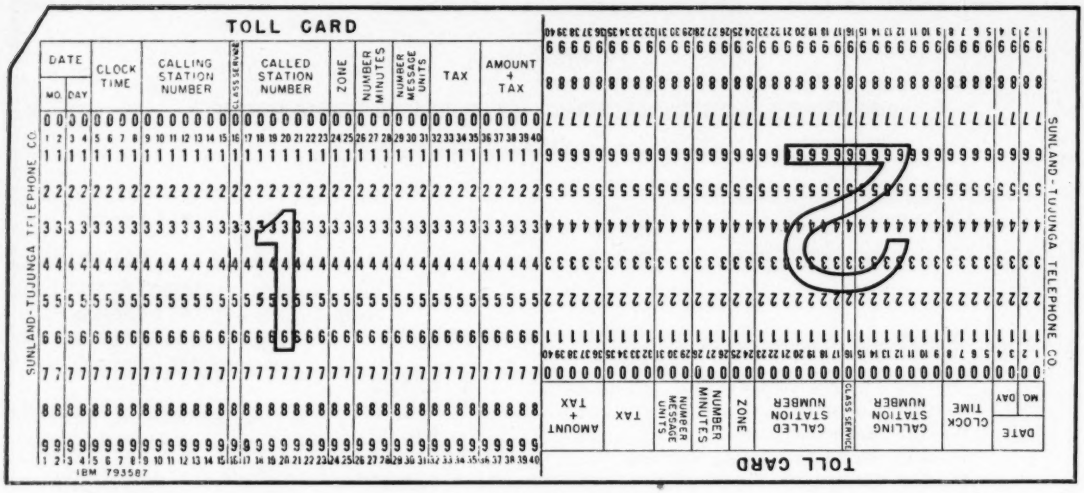


Figure 1. Tabulating Card Toll Ticket.

amount to $22,528 excluding floor space cost, general office overhead and stationery costs. The assumption was that these three latter categories of costs would be approximately the same no matter which billing methods were used. These annual charges compute to $0.26 per customer bill prepared with the recognition that the cost will be reduced to $0.20 per bill as station growth increases the volume through the billing department without requiring additional personnel or equipment.

Economics of Accounting Selection

As has been previously stated the conclusions reached in designing the Sunland accounting plan and the statements contained in the foregoing discussion of accounting operating procedures should not be misconstrued as a general argument for this type of operation.[3] In the single exchange operation of Sunland-Tujunga Telephone Company it was significant in the selection of accounting methods that 85% of the total tickets fell within the subscriber dialing range and accordingly lent themselves to automatic interpretation by unattended tape-to-card key punches. Only approximately 8% required manual key punching and 7% were coin box tickets that required no key punching or detailed billing.

If the percentage of tickets falling within the subscriber dialing range were to be materially reduced the advantages of automatic key punching would be correspondingly reduced. Many of the multi-exchange telephone companies operating with a single centralized revenue accounting and billing office may find the ratio of calls falling within the automatic ticketed, subscriber dialing range reversed in relationship to total toll tickets to be billed. If this is the case it is possible that the economic advantages of manual billing procedures or processes other than automatic key punch operation will be controlling and the economic justification may point to the use of other methods.

Work Flow and Control

The key to the entire automatic toll billing procedure at the Sunland office lies in the fact that the Strowger Automatic Toll Ticketing equipment produces a perforated tape from which it is possible to obtain a punched tabulating card. "Machines capable of automatically producing tabulating cards from continuous tape records on an unattended basis are produced by at least two business machine firms. International Business Machines equipment is employed in the Sunland system and a four-hole code is used on the tape. The column headings appearing on the tabulating card illustrated in Figure 1 denote the class of information falling in the respective columns and the order in which the data are decoded from

3. *Ibid.*, Pages 67 and 68.

the tape. Since only 40 vertical rows of figures are required to show all essential data on the tabulating card toll ticket and the capacity of the card is 80 rows, each card may be used twice, giving a complete toll ticket record in two separate billing periods and reducing the cost of tabulating card stationery to one-half of the cost for single usage.

"The four-hole code and tape position assignments used on the Sunland tapes to actuate a Type 797 Automatic IBM Key Punch and produce the tabulating card toll ticket are as follows:

DIGIT CODE

Digit	*Punch Positions (Top to Bottom, Fig. 2)*
1	1, 2
2	1, 3
3	1, 4
4	2, 3
5	2, 4
6	3, 4
7	1
8	2
9	3
0	4
Symbols	
Record start	1, 2, 3, 4
No third called code digit (used to adapt code to 6-digit as well as 7-digit directory numbers)	1, 2, 3

TAPE POSITION ASSIGNMENTS

Item	*Spaces*	*Tape Position*
Start	1	1
Date	4	2-5
Clock time	4	6-9
Calling station number	7	10-16
Calling station class of service	1	17
Called station number	7	18-24
Called station rate	2	25-26
Conversation time	3	27-29

"To facilitate an outside tape feed on the ticket printer or automatic key punch the SATT perforator places the above data on the ticket tape in reverse sequence (last item first). Spaces 29 thru 40 on the toll ticket, Figure 1 (number of message units, tax and total amount) are computed by IBM processes and do not appear on the tape for decoding."[4]

The billing operation itself begins when the data recorded on the tape is transcribed to IBM punch cards, via a Type 797 tape-to-card punch. Twenty-eight columns of information are punched into the card for each call and upon reaching the twenty-ninth column the machine is signaled to feed another card and stack the one just punched. In the event that the position of the punched tape does not produce twenty-eight columns of information the machine stops and throws on a signal light which brings an operator to investigate. It is at this point that the incomplete tickets referred to in Table III are segregated.

When this punching has been completed each day the cards are sorted by calling telephone numbers on the IBM electronic sorter Type 082. At this stage customers' requests for credit on misdialed calls are validated and allowed, if proper, by pulling the appropriate punched card. This is in accordance with the telephone directory instructions that if the customer reaches a wrong number he must dial the operator within four minutes and report to her the circumstances on the call. The operator records these particulars and prepares a ticket which is used as a credit pull ticket in the manner described. The card representing the wrong number is pulled from the deck and is not used for billing purposes. In the event that the card time does not correlate to the time recorded by the operator on the credit request or the telephone numbers are dissimilar no credit is allowed.

Insertion of rate charges in columns 29 through 40 of the card is performed each day by sorting into the toll card stack a master rate deck. The sort is on the columns representing called station rate (zone) and number of minutes. The master rate deck has punched in columns 29 through 40 every possibility of charge in each of the station rate zones for minutes 1 through 59. This charge information is automatically transferred from the master cards to the appropriate toll card on the IBM Type 517 gang summary punch, at the rate

4. *Ibid.*, Pages 65 and 66.

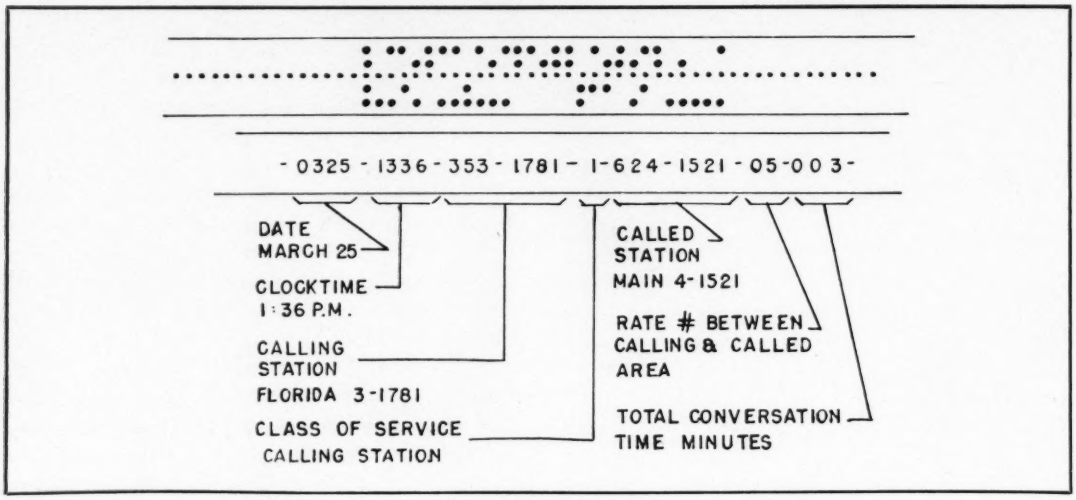


Figure 2. Typical Ticket Tape.

of 100 cards per minute. Upon completion of the rate extension operation the master cards are replaced in their file and the toll cards are held for association with manually key punched toll cards, approximately 8% of the total billable cards.

The manually key punched cards consist of long distance tickets received from the Bell System, Sunland office DSA operator tickets and telegrams. In the event that there are DSA operated tickets to points within the range of the automatic toll ticketing equipment the basic data is manually key punched up to column 28 into cards on the Type 24 key punch and then those cards are merged in with the cards prepared by the Type 797 automatic tape-to-card key punch and processed together therewith from that point. Other operator-prepared tickets and telegrams are used to manually key punch cards up to a point including the rate and then the Type 517 gang summary punch is used to insert the tax and total plus tax.

All of the cards for each day are processed through the IBM electric accounting machine which produces a total number of cards and a total dollar value to be used as a billing control total which is entered upon a control ledger. Following the obtaining of the control total the cards are sorted by telephone number and automatically interfiled with the previous days' cards through the use of IBM Type 77 collator. At the end of each ten-day period the total number of cards and the total dollar value are again tabulated and balanced to the sum of the daily controls and posted as a figure for intercompany settlement purposes. At this point, however, instead of totaling by day the ten days' cards are totaled by "banks" which consist usually of about 500 telephone numbers. The grand total of all the "banks" balances to the grand total of the ten-day period as entered on the control ledger.

The billing period at the Sunland office is from the 21st day of the month through the 20th day of the following month. At the end of this billing month, all cards for the three ten-day groups are collated together and this deck of cards represents all toll charges for the billing month.

Between the 21st day and the last day of each month a customer's toll statement, a customer's total bill including exchange and miscellaneous charges and a toll register are completed. All of these forms are completed on the IBM electric accounting machine, Type 405.

The operation to produce the toll statements consists of listing in detail each telephone call and telegram for which a charge is assessable to the customer. These are listed on the form shown in Figure 3 and contain coding to distinguish telegrams, collect calls and person-to-person calls. Itemized detail on each call is rendered to the customer and there is no bulk billing of any class of toll or message unit traffic.

SUNLAND-TUJUNGA TELEPHONE CO.

TOLL STATEMENT

DATE MO.	DATE DAY	PLACE CALLED	TAX	AMOUNT (INCL. TAX)

FL - 3	NUMBER	AMOUNT	TOTAL TAX	TOTAL AMOUNT
	MESSAGE UNITS			

CODE

T - TELEGRAMS

C - MESSAGES, COLLECT

P - MESSAGES, PERSON TO PERSON

P 1

Figure 3. Toll Statement.

Simultaneously with the listing of the customers' statements a toll and telegram summary card is produced by the 517 gang summary punch cabled to work together with the 405 electric accounting machine. This card includes the telephone number, the total charges plus tax and the tax, and is shown in Figure 4.

Upon completion of the customers' toll statements, the toll and telegram summary cards are checked for corrections, additions and deletions for the following reasons:

(a) *Tax free agencies*—All tax must be deducted from billing to certain government agencies.

(b) *Office calls*—Special treatment is required for certain toll charges by personnel of the Sunland-Tujunga Telephone Company.

(c) *In and Out*—Changes are required as a result of telephone number changes within the billing period. The total billing amount from the previous number is added to that of the new number in order that the customer receives only one bill.

(d) *Delinquent or Take Out*—Certain delinquent or take out accounts are held up from billing until all toll charges have been received or a notice imprinted across the face of the bill that it constitutes a partial billing.

(e) *Wrong Numbers; Delayed Toll* — Late charges must sometimes be applied to the billing.

(f) *P. B. X. and Multi-Line Subscribers*—All toll charges are consolidated to one card and master telephone number so that each such subscriber will receive only one bill. These are subscribers having lines or trunks which are consecutively numbered.

At this point the toll and telegram summary cards are ready for merging into production of the complete bill. (Figure 5) Past balance due cards are inserted as a result of a procedure to be described subsequently and exchange service cards are extracted from file.

Into the final billing operation in the sequence shown go the following types of cards:

(a) Master rent, or exchange service card. (Figure 6)

(b) Toll and Telegram summary card. (Figure 4)

(c) Service order cards codes "1" through "8".

Code	*Charge*
1	Directory and Advertising
2	Service Connection
3	Moves and Changes
4	Construction
5	Previous Balance
6	Credit
7	Rental Charge
8	Rental Credit

(d) Previous Balance (shown above as Code 5).

(e) Master name and address cards.

In merging these cards together on the IBM collator the master exchange service card is the "control card". Any cards in groups (b), (c), (d) or (e) that do not match a master rent card are

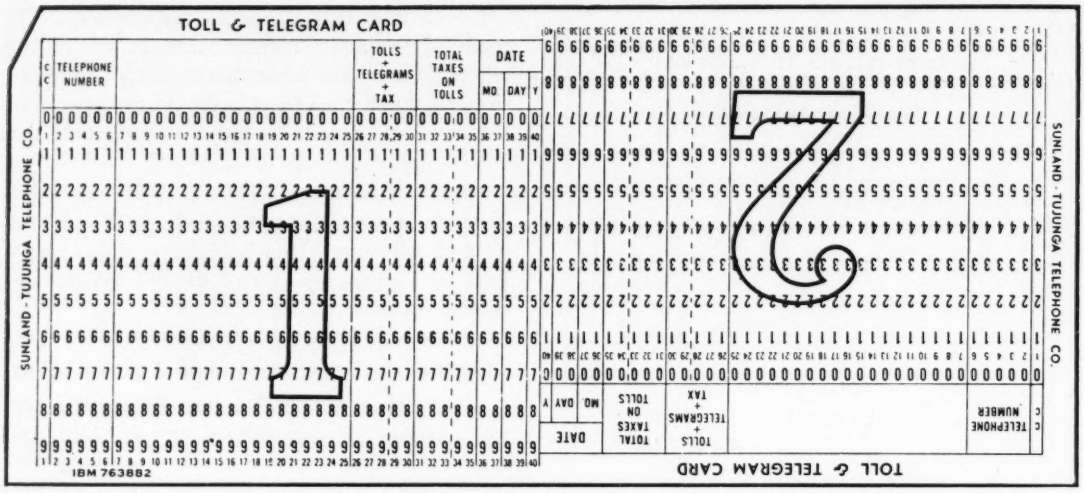


Figure 4. Toll and Telegram Card.

automatically rejected by the collator. This is a signal to the operator that there is an error in the card rejected or that a rent card is missing.

After merging and verifying the cards as described above the listing of the subscribers' bills proceeds. These cards are placed in the electric accounting machine and subscriber bills are printed at 80 lines per minute.

Simultaneously with the printing of the bill a summary card is punched by the Type 517 gang summary punch interconnected to the electric accounting machine with a cable. The summary card constitutes an accounts receivable card as shown in Figure 7 and contains the following information:

1. Telephone number
2. Total bill
3. Exchange rental
4. Tax on rental
5. Toll charges
6. Tax on toll charges
7. Previous balance
8. Service connection charges
9. Move and change charges
10. Directory and advertising charges
11. Rental charges
12. Rental credits
13. Toll and miscellaneous credits
14. Billing date

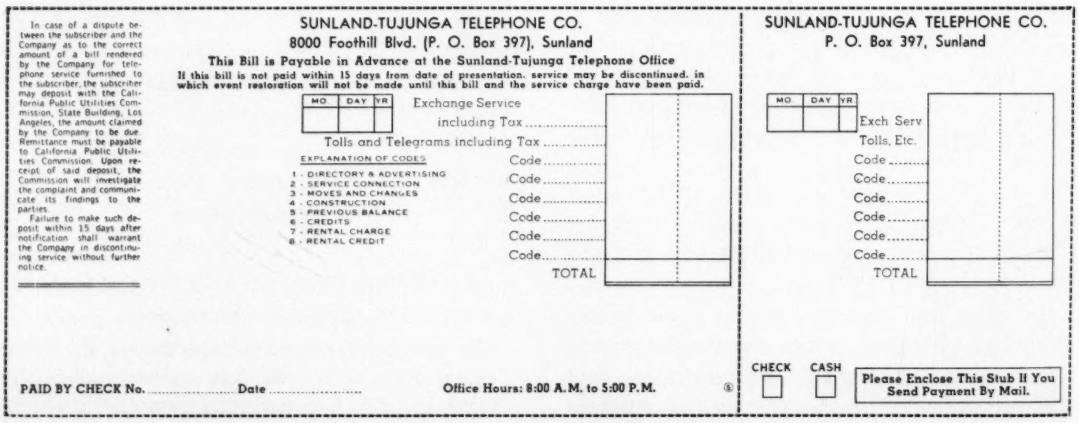

In case of a dispute between the subscriber and the Company as to the correct amount of a bill rendered by the Company for telephone service furnished to the subscriber, the subscriber may deposit with the California Public Utilities Commission, State Building, Los Angeles, the amount claimed by the Company to be due. Remittance must be payable to California Public Utilities Commission. Upon receipt of said deposit, the Commission will investigate the complaint and communicate its findings to the parties.
Failure to make such deposit within 15 days after notification shall warrant the Company in discontinuing service without further notice.
SUNLAND-TUJUNGA TELEPHONE CO.
8000 Foothill Blvd. (P. O. Box 397), Sunland
This Bill is Payable in Advance at the Sunland-Tujunga Telephone Office
If this bill is not paid within 15 days from date of presentation, service may be discontinued, in which event restoration will not be made until this bill and the service charge have been paid.
MO
DAY
YR
Exchange Service including Tax
Tolls and Telegrams including Tax
EXPLANATION OF CODES
1 - DIRECTORY & ADVERTISING
2 - SERVICE CONNECTION
3 - MOVES AND CHANGES
4 - CONSTRUCTION
5 - PREVIOUS BALANCE
6 - CREDITS
7 - RENTAL CHARGE
8 - RENTAL CREDIT
Code
TOTAL
PAID BY CHECK No. Date
Office Hours: 8:00 A.M. to 5:00 P.M.
SUNLAND-TUJUNGA TELEPHONE CO.
P. O. Box 397, Sunland
Exch Serv
Tolls, Etc.
CHECK
CASH
Please Enclose This Stub If You Send Payment By Mail.

Figure 5. Billing Form.

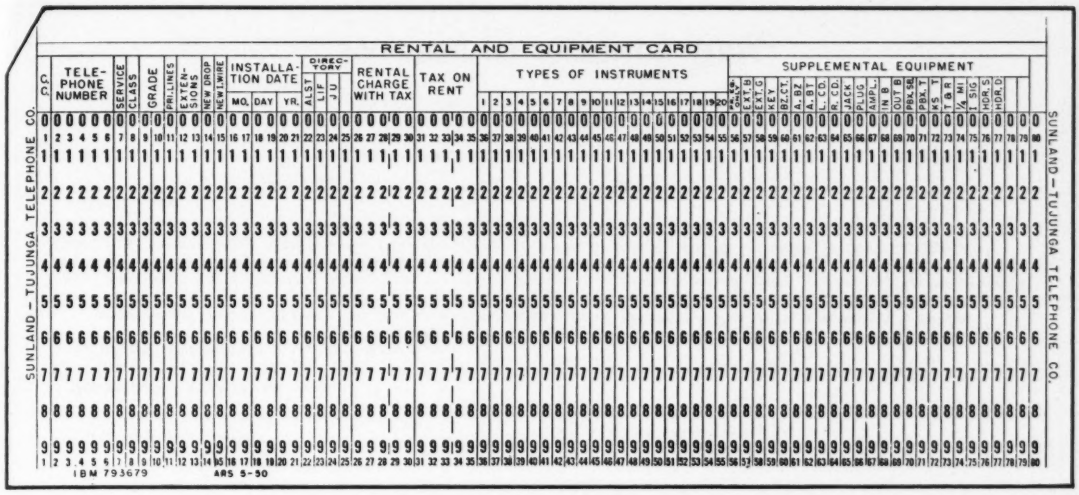


Figure 6. Rental and Equipment Card.

The bills are completed and mailed to the subscribers on the last day of each calendar month.

Immediately after the subscribers' bills have been produced the toll cards (individual toll cards, not summary) are placed in the electric accounting machine and a toll register is listed. This register is used for reference purposes by the exchange business office and contains a complete listing of every item of information in the first 40 columns of the toll card as shown in Figure 1 as well as a total of toll charges which agrees with the total of the tolls shown on the customer's bill.

The summary card produced at the time that the bill forms are prepared constitutes an accounts receivable card and is placed in an accounts receivable file. As payments are made through the mail or at the business office counter the accounts receivable card is pulled and punched with the date of the cash deposit to the bank. Partial payments are punched into significantly colored cards and filed behind the associated accounts receivable card.

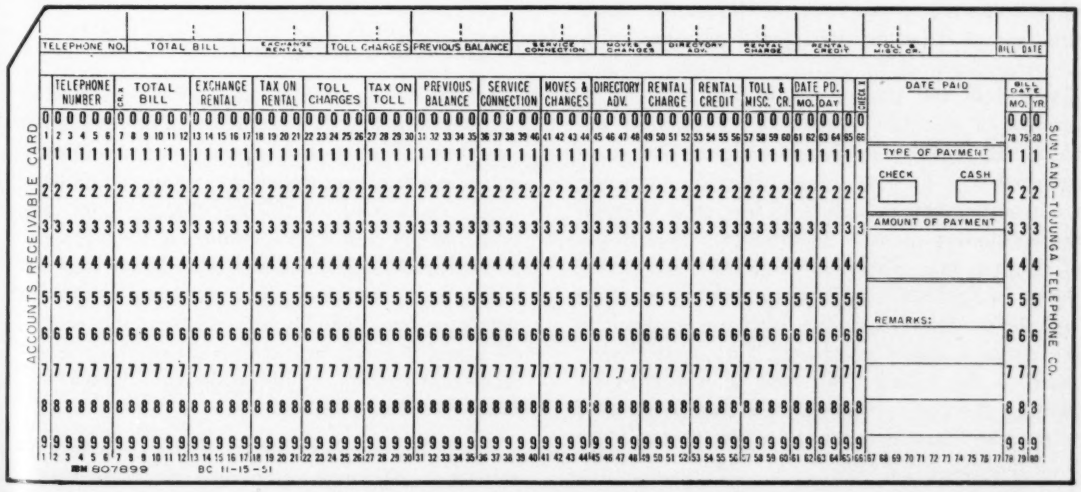


Figure 7. Accounts Receivable Card.

FINAL NOTICE OF CHARGES DUE

(Please disregard if your payment passed this notice in the mail.)

AMOUNT DUE $_____ DUE DATE — — TEL. NO. FL.

Possibly through an oversight you have neglected to pay this bill. Although service is subject to discontinuance 15 days after presentation of the bill, we have extended this period. However, unless your remittance is received in our business office by 5:00 PM of the above due date, we shall be obliged to permanently disconnect your service until the above amount plus a three dollar service charge have been paid in accordance with notice on your regular bill.

If there is any question concerning your account we shall be pleased to hear from you, either in person or by telephone.

SUNLAND-TUJUNGA TELEPHONE COMPANY
8000 FOOTHILL BLVD.
SUNLAND, CALIFORNIA

Figure 8. Final Notice of Charges Due.

On the fifteenth calendar day of each month all bills are due for payment and the cards remaining in the accounts receivable file are used to prepare a delinquent notice to the subscriber.

On this date the partial payment cards and the accounts receivable cards which represent fully paid accounts are balanced to the cash control figure which corresponds to the total of deposits of cash into the bank thus far in the month. After this type of balancing the partial payment cards are remerged with the accounts receivable file and placed into the electric accounting machine to produce a summary card which represents the individual subscriber's balances due. This summary card is in turn associated with subscriber name and address cards and processed through the accounting machine to produce a final notice of charges due. The final notice of charges due shown in Figure 8 is mailed in a window envelope and the accounts receivable cards are returned to the open accounts receivable file. Immediately prior to the billing (the 20th of the calendar month) the open accounts receivable file is used to prepare balances forward for insertion as Code 5 on the customers' bills.

Since the accounts receivable card, shown in Figure 7, contains the complete history of all of the charges to the customer and the record of his payments, it constitutes the "ledger" on the telephone account for the given month. These cards are retained as a "ledger" for the legal period before destruction.

Figure 9 is a complete Flow Chart description of the above described billing procedures.

Programmed Improvements

In November of 1954 a later model electric accounting machine, Type 403, will be installed at the Sunland office and provide several improvements in operation through greater speed and flexibility. As a result of the installation of the new type machine and a consolidation of the toll statement, the bill form and the toll register into one single form, the total alpha accounting machine operating time will be reduced from the current 80 machine hours to less than 20 machine hours. The combination of improvements which will bring this change about are:

1. An increase in listing speed from 80 cards per minute to 100 cards per minute combined with a faster and more flexible automatic carriage.

APPLICATION Automatic Customer Billing

COMPANY Sunland Tujunga Telephone Company
Sunland, California

OPR.	DESCRIPTION
1.	Automatic Tape-To-Card Punch. Punch Toll Cards.
1a.	Key Punch other toll charges.
2.	Sort Toll Cards to Telephone Number.
3.	Pull wrong numbers.
4.	Sort together Toll Cards and Rating Cards on Zone and Minutes.
5.	Gang Punch Extend Toll Cards.
6.	Sort apart Toll Cards and Rating Cards. Refile Rating Cards.
7.	Establish Daily Billing Controls.
8.	Collate "today's" Toll Cards with those of previous days; then collate ten-day groups at end of accounting month.
9.	Write Toll Statements. Automatically summarize Toll Summary Card.
10.	Pull Accounts Receivable Cards from Cash Receipts. List Deposit Slip for bank deposit.
11.	Automatically summarize delinquent accounts, on 15th of month.
12.	Collate Delinquent Summary Cards and Name and Address Cards.
13.	Write "Blue Notices".
14.	Sort to separate Summary Cards and Name and Address Cards.
15.	At billing time, automatically summarize outstanding accounts, and produce Unpaid Balance Summary Card.
16.	Collate together (1) Toll Summary, (2) Exchange Service Master Card, (3) Unpaid Balance Summary, (4) Other Charges, and (5) Name and Address Cards.
17.	List Bills, and automatically punch a summary card, which becomes the new Accounts Receivable Card.
18.	Sort apart the cards used in Billing.
19.	Interpret Accounts Receivable Cards at the IBM Service Bureau.

DATE

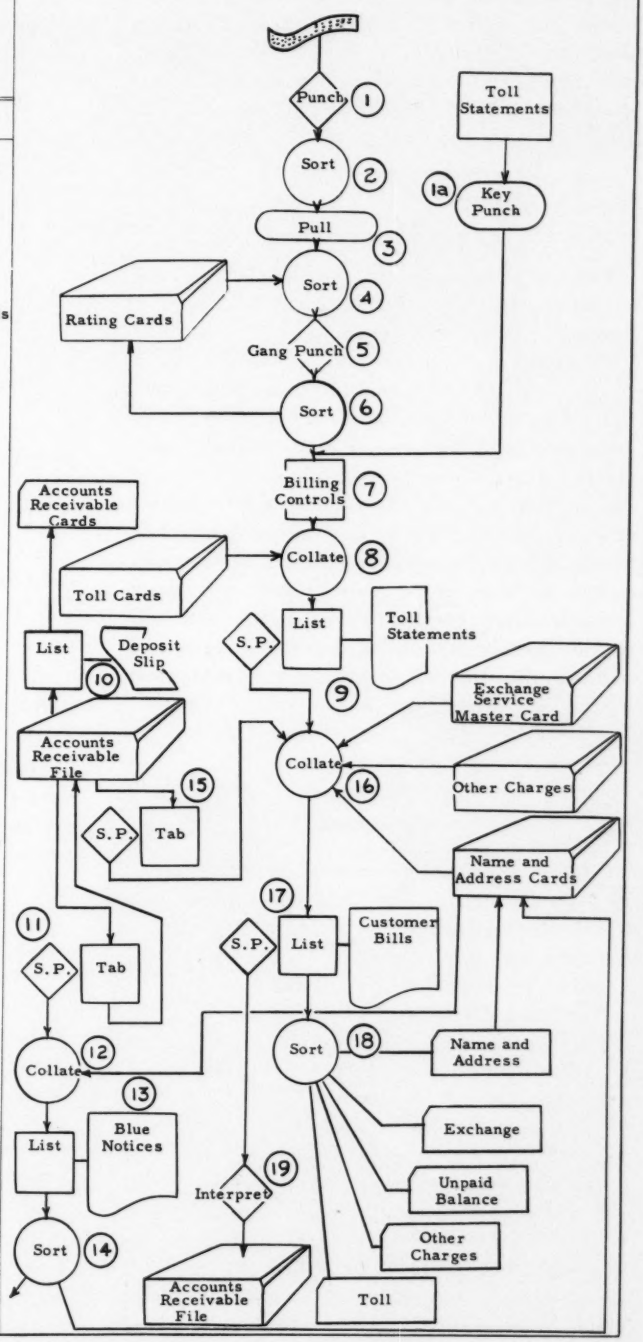


Figure 9. Flow Chart.

2. A combining of the rent and exchange service master card information with that on the customer name and address cards to eliminate two or three cards for each subscriber and reduce the master name and address and exchange rent card file from 26,000 cards to approximately 7,000 cards.

3. A combining of the billing form, the toll statement and the toll register so that all can be written simultaneously, with one operation.

The question might be asked: if as described in previous sections of this article the present accounting system may continue to be used up to 9,200 accounts compared with the present 7,200 accounts, why is it advisable to bring in an even faster Type 403 machine and consolidate the three forms into one? The answer is that the increased monthly rental charges to the telephone company for the faster Type 403 machine will be largely offset by the paper savings in reducing three forms to one and a reduction of machine time from the current 80 hours to less than 20 hours will create a much larger cushion for expansion and will provide revenue accounting department personnel with free time that will be utilized for non-revenue accounting duties.

Potential for Growth and Other Accounting Adaptations

Experience of the revenue accounting department at the Sunland office has demonstrated that punch card equipment has within it capability of handling increasing volumes at decreasing unit costs. Up until January, 1948, the Sunland revenue accounting department handled all of the billing on its own premises by the previously referred to manual basis of typewriters and adding machines. During the years 1948 and 1949, an interim procedure was used of preparing the basic toll statement form on the Sunland premises and punching summary cards on a manual key punch and then transporting the summary data to a nearby IBM service bureau which processed the summarized data and produced a subscriber bill form mechanically at a stipulated standard service charge per month. In January, 1950, the Sunland office placed the punch card equipment upon its own premises and from that point forward handled all phases of its revenue accounting billing.

In January, 1950, the Sunland office used the following punch card machines on its premises to bill 4,800 accounts:

1. 031 duplication punch—1
2. 043 tape-to-card punch—2
3. 082 electronic sorter—1
4. 405 alpha accounting machine—1
5. 517 gang summary punch—1
6. 921 automatic carriage—1

Total annual charges for renting this equipment were $6,600 including excise tax.

From January, 1950, to June, 1954, the number of accounts billed increased 50%—from 4,800 to 7,200. The number of employees (three) stayed the same. The punch card machines were modified as follows:

1. One tape-to-card machine was returned to the IBM Corporation because it was not needed.

2. One Type 077 collator was added to the equipment.

3. The Type 031 duplicating punch was changed out for a Type 026 printing card punch.

4. The type bar and counter capacity of the alpha accounting machine were increased.

Three additional card storage files, two special purpose desks and one mobile card storage rack were purchased. Three standard office desks were released to other departments. One wall of the revenue accounting room was extended to provide 178 additional square feet of floor space.

The total increased annual charges as a result of adding revenue accounting capacity to permit a 50% increase in the number of accounts billed was $250.00 per month—$217.00 per month net additional machine rental plus $17.00 per month fixed charges on file and storage equipment and floor space. As mentioned previously it is anticipated that the number of accounts may be increased up to 9,200 without additional revenue accounting costs other than the necessarily increased quantity of paper forms.

The revenue accounting equipment at the Sunland office stands ready to itemize on the customer's toll statement those calls dialed by him on a nationwide basis as the industry converts to nationwide subscriber toll dialing. Minor modifications will include revision of toll card and toll statement forms to provide three additional digits

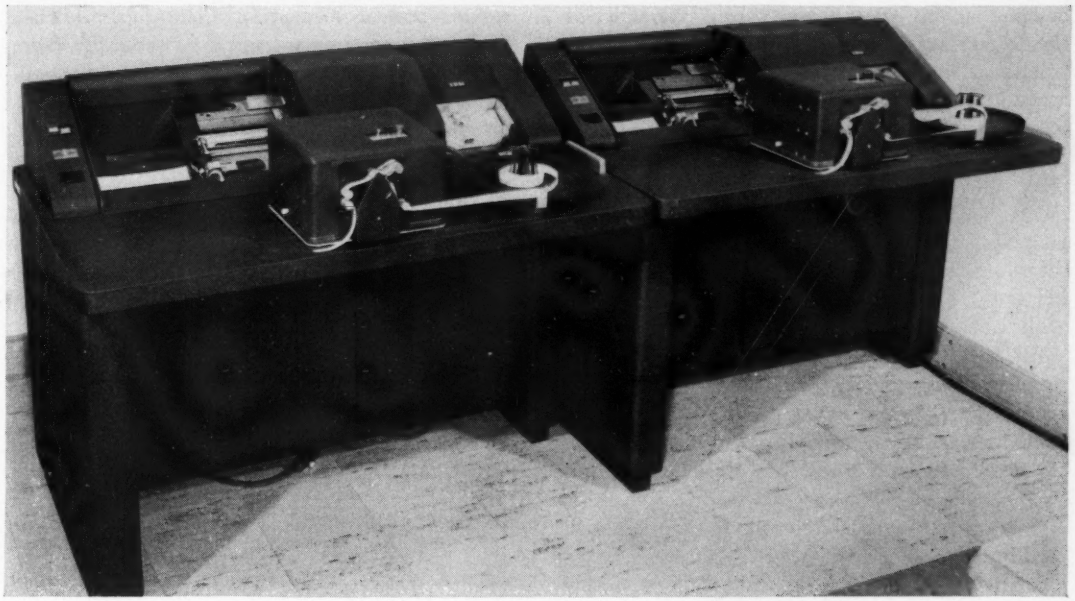


Figure 10. Two Type 042 IBM Automatic Key Punches for Decoding Perforated Tapes.

Figure 11. Left to right: Type 405 IBM Printing Tabulator, Type 517 IBM Summary Punch and Type 082 IBM Electronic Sorter.

designating the national numbering plan area of the called station.

This article has dealt solely with the revenue accounting adaptations of punch card equipment in a telephone company. However, where volume justifies it is a perfectly practical procedure to place other applications on the punch card equipment. For example, entire payroll procedures are adaptable to punch card production; plant accounting, inventory control and certain types of toll traffic studies may readily become a product of the same punch card equipment.

All punch card equipment is leased from the supplier on a monthly rental basis. A lease arrangement provides flexibility to the telephone company in that new and improved machines may be substituted with ease for older machines and the use of machines no longer needed may be readily discontinued. Recently in some punch card installations the simplification of excise tax to a flat 10% instead of the 15% and 25% previously in effect resulted in a reduction in punch card machine requirements. The lease arrangement permitted the telephone company to take immediate advantage by discontinuing the use of one or more machines and reducing the monthly rental charges therefore.

Punch Card Service Bureaus

Previous reference was made to Sunland revenue accounting department making use of the IBM service bureau located in Los Angeles. These service bureaus are scattered throughout the nation in strategic cities and provide punch card availability to many organizations that are not able to economically justify installations on their own premises. For a standardized fee the service bureau will summarize the data submitted by the telephone company and prepare required toll statements and billing forms. In many instances the data may be prepared for the punch card service bureau by a night operator or other telephone company employee who is available for fill-in work.

What Lies Ahead

With the prospects of ever increasing subscriber toll dialing and continued growth in Independent company territories there appears to be no limit to the improvements and mechanization that the resourceful Independent telephone man will be able to make to his billing and accounting procedures as well as to his traffic operating methods. Since this article has stayed closely to a factual recording of what has happened at the Sunland accounting office it has only hinted at the vast reservoir of improved efficiency and cost reduction that may be tapped in the future. As with almost all mechanical and electronic business tools which are beginning to emerge, the potential efficiencies and savings are limited only by the ability of telephone executives to meet the challenge of finding new ways to use them.

THE STROWGER LINEFINDER TEST SET

Probably every experienced switchman has at one time or another reinstalled a linefinder on a shelf, spent time tightening the bank clamps and adjusting the wipers, and has then given the switch a final test, only to find that, because of some oversight or error in the repair work, it is necessary to remove the switch from the shelf again.

This annoying experience need not trouble switchmen in offices where the new Linefinder Test Set is available. A line-finder, once removed for repair or adjustment, can be *completely* checked for proper operation before being returned to the shelf. Besides providing convenient keys and lamps with which to make the standard tests, the Test Set simulates the linefinder common equipment, so that operations involving the common equipment can be tested while the switch is off the shelf.

The equipment consists of three relays, five lamps, five lever keys, two test prods, and a number of binding posts for convenience in making various connections. This apparatus is contained in a box mounted on a base with a switch stand. The stand is very similar to the familiar switch stand used when working on switches, but it is somewhat shorter than usual since only linefinders need be accommodated.

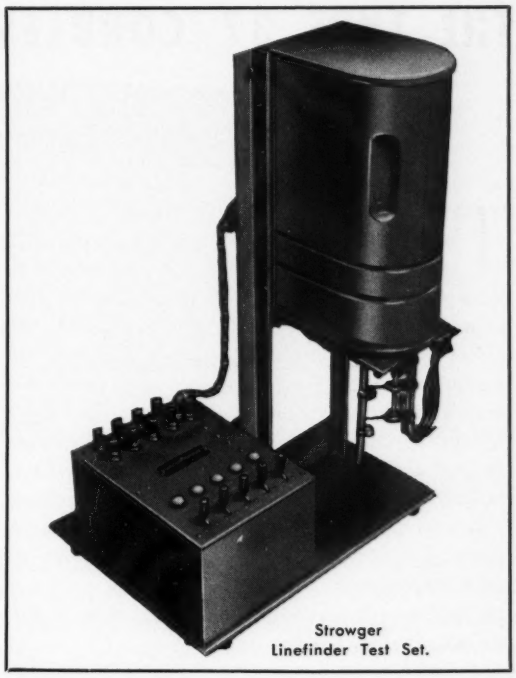
To use the Test Set, the testman goes through a "check-list" of some twenty-six operations. Most of the tests are made by operating keys, but a few involve touching the wipers with the test prods. Operation is very simple. After a little practice, it is possible to make all the tests in a couple of

minutes. All the tests give a definite positive or negative indication in the form of a lamp lighted or extinguished, or some switch action or lack of it.

If a linefinder passes all the tests successfully, the testman can be sure that: (1) There is continuity of all the switch leads to the switch jack points; (2) There is continuity of the "break" contacts of all the relays when the relays are normal; (3) None of the "break" contacts are shorted when the relays are operated; (4) There is continuity of the "make" contacts of all the relays when the relays are operated; (5) None of the "make" contacts are shorted when the relays are normal; and (6) There is continuity in all wiper leads.

The Test Set is not intended to be used for routine testing or minor maintenance of linefinders. Such functions are better performed with the switch on the shelf. However, if it is necessary to remove the switch from the shelf, the Linefinder Test Set will make it unnecessary to insert and remove the switch repeatedly in order to test it under operating conditions.

—R. J. MAGUIRE, *Chicago*



Strowger Linefinder Test Set.

ATEA "MIXED SERVICE" TELEPHONES

The mixed service telephone provides a very convenient solution to the problem of furnishing combined internal and external telephone service in businesses and homes where the number of stations is too small for PABX working and where efficient service calls for the basic facilities given by a modern PABX. Automatique Electrique, S. A., Antwerp, Belgium, has brought its range of ATEA Series 600 mixed service instruments to the stage where, by the use of one instrument or another, or a combination of types, standard equipment is available to meet virtually any requirement.

ATEA Telephone Type 616 of the 600 Series.

The two types for which there is perhaps the greatest demand are the 616 and 626 models represented by the illustration herein. Both instruments provide for six internal lines, with the Type 616 catering to one central office line, and the Type 626 to two. The general facilities are the same and include the free transfer of central office calls, from one station to another, the holding of a central office line for the purposes of a local information call, operator and secretarial service, full secrecy on external calls and universal night service. For most installations a local common talking circuit presents no inconvenience, but to meet those cases where secrecy is required on the local circuit, instruments are available which are similar to the sets described but with the secrecy facility. This is a recent development of Automatique Electrique, S. A., and secrecy is achieved by the provision of a simple relay box which also contains a rectifier unit. With the addition of the relay box rectifier unit and some additional wiring, existing 616 and 626 installations can be readily modified to incorporate the local link secrecy facility.

V. ANTHONIS, *Antwerp*

THE TYPE 37 CORDLESS P-B-X SWITCHBOARD

By R. O. STOEHR

Development Engineer, Automatic Electric Company

SYNOPSIS: *Reason for redesign — cabinet exterior and front panel — lever key handles—emergency ringing generator—attendant's telephone —capacity.*

THE Private Branch Exchange Cordless Switchboard is a single position turret-type switchboard designed to meet the telephone needs of small business and industrial establishments. Its circuits are arranged for local manual service and for connection to either automatic or manual public exchanges. There are no plugs nor jacks, and all connections are made by operation of the appropriate lever keys. The attendant can set up local station-to-station calls, and calls from local stations to the automatic or manual central offices. It is also possible to handle delayed calls, hold incoming calls from a public exchange, and set up night connections. The switchboard is attended full-time or only part-time, depending on the traffic it is required to handle.

Reason for Redesign

The design of present-day P-B-X equipment can no longer be based on equipment efficiency alone, but must consider the style of office furnishings that will surround the switchboard and the appeal it must have for the prospective customer. The executive who takes pride in his modern office will hesitate to accept a "black-faced box" no matter how efficient its operation. It was with these factors in mind that the development of the Type 37 Cordless Switchboard was undertaken.

The switchboard is compact and may be conveniently placed on a desk or table. It is not necessary to fasten the unit, as its weight will keep it in position. Felt feet on the base prevent furniture marring.

Cabinet Exterior and Front Panel

The cabinet exterior and front panel have been styled in line with modern office furnishings, both in physical appearance and color, with emphasis on simplicity. Escutcheon mounting of panel equipment was stressed for appearance and for ease of maintenance. The panelled cabinet of previous switchboards was replaced by a one-piece mahogany unit made to fit around the base assembly and to overhang slightly the sloping front panel. The panel is firmly supported on three sides by the cabinet. For access to relay equipment, the cabinet may be readily removed by loosening the three screws fastening it to the base. The slight inward bevel of the cabinet leading edges tends to accentuate the slope of the panel.

The front panel is finished in a matte gray-green rather than in the black usually characteristic of equipment of this type. The panel slope not only enhances the appearance of the turret but also facilitates operation and aids in recognition of the trunk and station designations. Vertical connecting link designations are engraved on gray-green escutcheons, which are designed to match the panel, and which mount all keys and lamp jacks except the "Hold" keys on the 20-line board.

To provide a pleasing contrast with the gray-green panel, the lever key handles are molded of bright red, green, and white plastic. No longer round, the handles are curvilinear and taper slightly toward the attendant. Because the top and bottom surfaces are more nearly flat, operation is easier and broken fingernails are fewer. The handles, because of their shape, are not threaded onto the key cam, but are pushed on and held by friction fit. These handles may be removed with a special tool and be replaced by merely pushing on. The trunk keys, for making connections to and from the public exchange, are provided with red key handles. Line keys for interconnection of local calls, or connection of local to public exchange calls, are provided with green handles. Attendant

Figure 1. The 20-line cordless P-B-X Switchboard.

listening keys, for setting up and monitoring all calls, have white key handles. Hold keys are provided for the trunk circuits, and one key for each local line serves also as a ringing key. One of the attendant's listening keys is used as a ringing reverse key, thus making possible selective ringing of two stations per line. Turn keys with green handles are mounted on the extreme right escutcheon for night alarm cut-off, operation of emergency ringing generator, and battery cut-off. All connections are made and broken by operation of the appropriate lever keys by the attendant.

To accentuate the key handles, red plastic lamp caps are used for disconnect supervision, white plastic lamp caps for line designations, and green plastic lamp caps for trunk designations. Only the plastic opal protrudes beyond the escutcheon and no unsightly metal rim is visible. When lit,

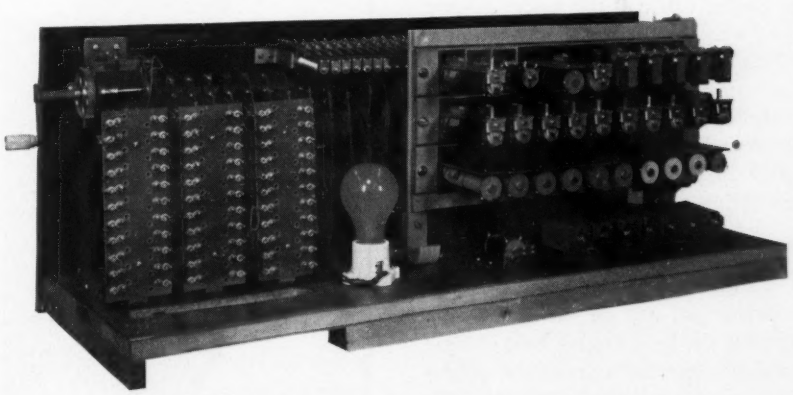


Figure 2. Rear view (cover removed) 20-line cordless P-B-X Switchboard.

the lamp caps glow uniformly and are readily seen from any direction. The caps may be removed with the standard removing tool.

Above the horizontal row of trunk and line lamps an all plastic designation strip conceals the upper escutcheon mounting screws. This strip is made from a clear, flexible plastic and is sealed at the ends to exclude dust. A Bristol board designation card is laid inside the plastic strip, and the strip is snapped in place on its mountings. Being tough as well as flexible, the strip may be removed by gently prying it from its mounting brackets. With this type of designation strip the entire height of the designation card may be utilized and may be read more easily.

Emergency Ringing Generator

Should the main source of ringing current fail, an emergency Alnico ringing generator is provided. The crank handle of this generator extends through the right side of the cabinet and may be removed when not in use.

Attendant's Telephone

The attendant is provided with a desk type Monophone either with or without dial, depending on whether local stations are equipped with manual or automatic instruments. When the local stations are manual, the attendant must dial all outgoing calls into the public exchange office. The Monophone line cord extends from beneath the cabinet, and the instrument may be conveniently placed anywhere on the desk.

Capacity

The Type 37 Cordless Switchboard is available fully equipped with either 10 local lines, 4 trunks and 5 link circuits, or 20 local lines, 5 trunks and 5 link circuits, and for either 24-volt or 48-volt operation. Both talking battery and ringing current may be supplied either locally or over central office leads. The board may also be equipped with line relays should the local line loop resistance be more than 200 ohms but not more than 500 ohms. Operating limits are 400 ohms for exchange trunks and 700 ohms for any combination of line and trunk.

ATEA POLICE CALL SYSTEM

A recent development of Automatique Electrique, S. A., Antwerp is a police call system for police and public use. A first installation is in operation in the Commune of Berchem in the Province of Antwerp, Belgium. By pressing the call knob on the highway unit, a policeman or member of the public can call the police station and converse by means of the built-in transmitter and loud speaking unit. Abuse by the public is controlled by the operation of a loud ringing bell (day) or powerful beacon light (night) when the press button is pressed. The bell or light is under the supervision of the police station and it cut off when the police station answers. Interruption may also be effected by means of a key which the policeman on duty carries. To summon a policeman to a call unit, the operator at the police station operates the appropriate call key on the call system switchboard, causing the loud ringing bells or light beacons to function along the route of the policeman's beat. The system operates directly from the power mains and each highway unit is entirely self contained.

L. VLAMINCKY, *Antwerp*

Highway unit for Police Call System installed in commune of Berchem, Province of Antwerp, Belgium.

AUTOMATIC RECORDER-ANNOUNCERS

By E. S. PETERSON

Project Engineer, Automatic Electric Company

SYNOPSIS: *Voice recording and announcing equipment in telephone systems — design requirements — types of Recorder-Announcers — function and operation—summary.*

THE conversion of a telephone exchange from manual to automatic not only provides facilities for the automatic switching of local calls, but in addition offers the operating organization an opportunity for employing special announcing equipment for the automatic handling of most "special service" calls, thus further reducing the need for operating personnel.

Typical of such calls are time announcements; intercept service for disconnected lines, changed numbers, unused selector levels, wrong numbers, or inaccurate dialing; emergency announcements; weather forecasts; posted delays on toll calls; instructions on calls from paystations; conversation timing; and subscriber education during manual to automatic conversion periods. In rural communities an additional service is sometimes required where an operator serves as a dispatcher for volunteer firemen who call in for the fire location.

Except for attempted calls to changed numbers, which must be handled individually by an intercept operator, these special service calls can now be handled by various types of Automatic Recorder-Announcers. This article discusses the four principal types now being offered by Automatic Electric Company.

One of the design requirements was that the recorded announcement should approximate as closely as possible the "personal" voice characteristics of the operator and should not be broken by pauses due to switching between drums or discs, or by changes in pitch that indicate that the announcement is recorded instead of being spoken. A further requirement was that the service must be easy to use and the equipment simple to operate so that commercial and other announcements can be easily and inexpensively recorded without the need for trained personnel.

These requirements were met through the use of a continuous recording on iron oxide-impregnated magnetic tape. This magnetic tape is plastic for time announcements and a tough rubber compound for other announcements.

Types of Automatic Recorder-Announcers

Over a period of several years Automatic Electric Company has developed four types of Automatic Recorder-Announcers, each designed to meet a particular need. All of them have magnetic-type recording media, which have proved more practical than systems using a disc-recording or a photographic film record and photoelectric cell for scanning. No processing of the recording medium is necessary before re-recording since the original recording is erased automatically during the next recording.

The Automatic Time Announcer

The Automatic Time Announcer is the first of the Automatic Recorder-Announcers designed and developed by Automatic Electric Company.[1] It provides "time of day" announcements to telephone subscribers when a designated directory number is dialed.

The time of day announcements are on a magnetic tape. This tape is a copy of a master recording made at the factory by a professional announcer. Announcements are made throughout the 24-hour period of each day at fifteen-second intervals. In addition to the time of day announcement, a separate tape recording makes commercial or public service announcements of up to six seconds length. Six different commercial announcements may be recorded on the tape, which has

1. For a description of the Automatic Time Announcer see "The Automatic Time Announcer", by E. S. Peterson. *The Automatic Electric Technical Journal,* January, 1951.

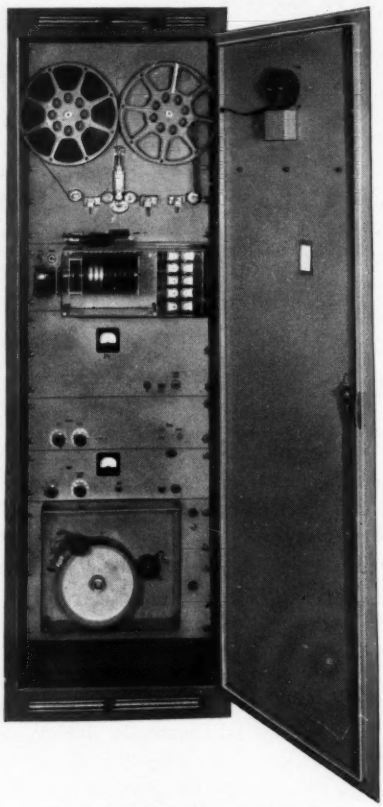


Figure 1. Automatic Time Announcer.

provision for six channels, and is mounted on the rim of a metal drum. For an example, see Figure 2.

One commercial announcement precedes each time announcement; the complete cycle of one commercial and one time announcement requires fifteen seconds. The commercial announcements are made consecutively on channels one through six, and then repeated continuously. As the machine is usually furnished, a subscriber hears only one complete commercial and one time announcement. Upon seizing a time trunk he first receives ring back tone until the starting cycle of the commercial; then he hears the commercial, then the time, and then busy tone until he hangs up. If it is desired that the subscribed stay on indefinitely, there is optional wiring.

Alarms—Alarm equipment is provided to give instant notification of power failure or any abnormal operation of the Time Announcer. In case of power failure (even for only a fraction of a second), an alarm is operated, but the machine re-operates when power is restored. If the tape breaks, (which is almost a physical impossibility) the Announcer stops instantly and closes a circuit to the exchange alarm equipment. Abnormal operation of the tape—that is, moving at the wrong part of the cycle, or standing still when it should be moving—will also bring in an alarm.

When a spare machine is desired, the two machines are arranged to run simultaneously, and the audio circuit of the spare unit is automatically switched into service in case of failure of the first machine.

Power Supply—Accurate timing is assured by a synchronous motor-driven master clock which operates on 115-volt, 60-cycle commercial power. If the power available is not accurately controlled, a crystal-controlled oscillator and amplifier can be used to drive the clock motor; this method of control gives even more accuracy than is usually provided by commercial current. Fast tape rewinding and a declutching arrangement on the cams

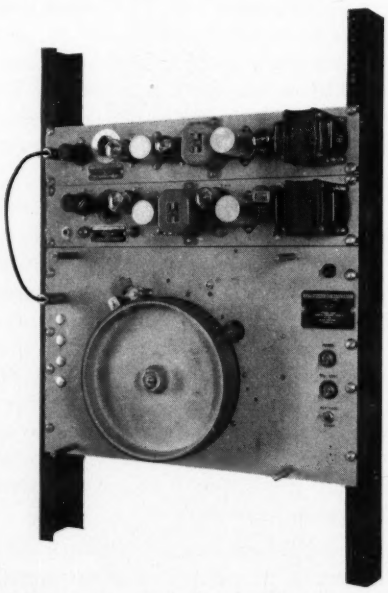


Figure 2. Type MCF Automatic Recorder-Announcer (Multi-Channel, Fixed Message Length)

of the master clock permit resetting the Announcer quickly and accurately.

Mounting — The Automatic Time Announcer comprises six equipment panels assembled on a 19″ relay rack and housed in a steel cabinet 22″ wide, 18″ deep, and 68″ high.

Automatic Recorder-Announcer Type MCF (Multi-Channel, Fixed Message Length)

It has been the usual practice in telephone offices to provide operator intercept of attempted calls to disconnected lines, changed numbers, unused selector levels, or wrong numbers. In city exchanges, this offered no particular electrical problem, assuming that an intercept operator was located in the same office. However, intercepting took up the operators' time.

The Type MCF Automatic Recorder-Announcer provides means for intercepting and handling all these types of calls, except changed numbers; the latter would be routed directly to an intercept operator.

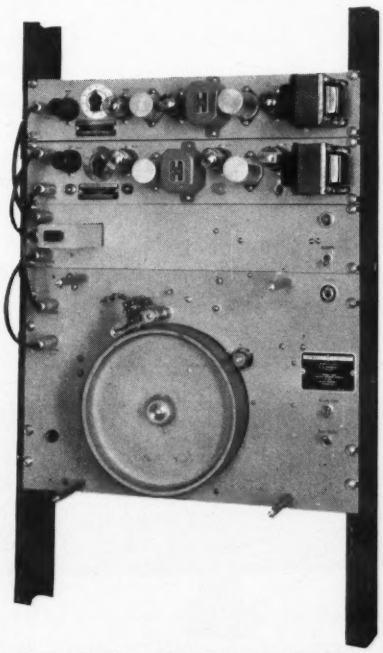


Figure 3. Type VML Automatic Recorder-Announcer (Variable Message Length).

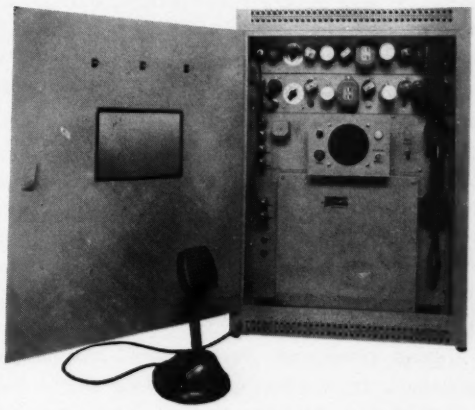


Figure 4. Type FML Automatic Recorder-Announcer (Fixed Message Length).

Outlying offices, trunking into a main office, have always offered a problem, since trunks must be made available for intercepting calls from the outlying offices. Tandem operation, that is, trunking through several offices, made the problem even more difficult, or practically impossible. It also confused the subscriber. An Automatic Recorder-Announcer installed in each of the outlying offices can easily solve the problem of intercepting such calls.

In existing offices, intercept circuits now employed in both the main offices and outlying offices can be readily converted to machine answering instead of operator answering. Circuit drawings normally used today have been modified for machine answering.

As explained above, there are endless uses for this type of a machine; intercept service is only one use. On post-pay paystation calls, there is occasional confusion, since the called party does not always recognize that the call is being made from a paystation. In some cases the called party hangs up before he can be informed that he should wait until the calling party has deposited the coins. Relay equipment is required between the paystation line and the regular line equipment to close momentarily the recorded voice to both ends of the line.

In a toll center, the Automatic Recorder-Announcer can be provided to explain delays in

handling toll calls. During peak traffic loads, when operators are already busy pushing through as many calls as possible and all circuits are tied up, this unit can inform the originating operators of the delay, avoiding confusion and getting more calls completed.

On exchanges employing time disconnect, instead of disconnecting both parties at the end of the timed call, an Automatic Recorder-Announcer can be used for informing the calling party that he should terminate the call. Circuit conditions must be analyzed in each case to determine advisability of applying this service.

During conversion from manual-to-automatic operation, the machine can be used in the subscriber education program. Dial, busy, and ringback tones can be recorded and the installer can familiarize the subscriber with the new tones by playing back the recorded tones to each line.

The machine can also be used for emergency purposes since recordings can be made on very short notice.

This machine, by means of a two-step (two diameter) friction-drive bushing on the front of the machine, can be changed over quickly to run at slow speed (6-second cycle) or at fast speed (12-second cycle). With this arrangement the machine is readily adaptable to different lengths of messages or different uses. The machine can be arranged to run continuously, or on a start-stop basis when seized by intercept or by trunk circuits. On a start-stop basis of operation, the subscriber, in some cases, can be cut in at the beginning of the cycle, providing circuit operation such as terminal-per-station, terminal-per-line, selector levels, etc., permits. Intercept equipment in each office concerned, whether a new or old office, must be properly analyzed when conversion to machine answering is desired. Because the messages are short (6 or 12 seconds) cutting in at any part of the message would not confuse the subscriber.

In outlying offices, tandem operation—one or two recorded messages—can be provided for intercepting calls on the Announcer. Two messages can discriminate between disconnected lines and dead levels. Usually one such message as follows is sufficient: "This is a recorded message, please dial operator". The subscriber has the satisfaction of being informed that some error has occurred and dials "operator" to receive proper instructions.

In main offices or outlying offices the advisability of using more than one message on the machine for intercept purposes depends on circuit facilities, as explained above. In some cases, messages for other purposes—paystation, time disconnect, announcements of toll service delays, etc.—can be incorporated in one machine, since there are facilities for equipping five record-playback heads or tracks.

Operation—As explained, the Time Announcer loop recorder used for advertising purposes and the Automatic Recorder-Announcer employ the magnetic type of recording. A metal drum, approximately 8″ in diameter, is equipped with a rubber base magnetic-type of recording medium stretched around the outer edge of this drum with which the record-playback heads make contact. This machine uses a rubber recording medium that produces no appreciable wear on the recording track and the contacting surface of the recording head. Most other recording media, if used in a similar manner, would result in considerable wear of the contacting surface of the head. The drum is driven by a dependable rubber friction drive. A slow-speed motor is used to simplify the drive speed reduction mechanism, and to give long life to the speed reduction and motor bearings.

With each record-playback head, a playback amplifier is required. This playback amplifier has sufficient power to play the recorded message to 30 subscribers at one time. A recording amplifier erases and records messages in the same operation. Patch cords, accessible from the front of the machine, connect the equipment in record or playback position.

To record a new message, the procedure is as follows: A busy switch, which takes away the

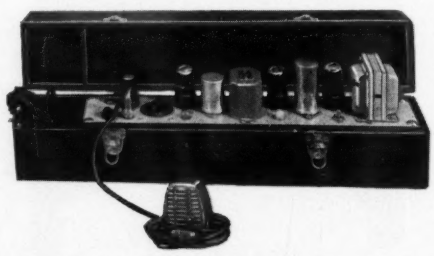


Figure 5. Record amplifier mounted in a carrying case, with microphone and long patch cord.

control of the starting and stopping of the machine from the relay circuits, is operated on the front panel of the loop recorder. If the drum has been rotating, it will stop at its normal stopping point. The patch cord associated with the particular head or track to be used for a new recording is removed from the playback amplifier jack. This patch cord is now inserted in the "Erase" jack of the record amplifier, either mounted with this equipment or in a portable case (see Figure 5). The drum is now rotated by operating a "Playback" switch on the loop recorder panel. It is allowed to rotate approximately 3 or 4 revolutions, erasing the particular track connected to the "Erase" jack. The "Playback" switch is now placed in the center position, allowing the drum to stop at its normal stopping point automatically. The patch cord is placed in the "Record" jack, and by means of the microphone, a new recording can be made. The "Start" switch is momentarily operated, causing the loop drum to rotate. The announcement is then recorded during the single revolution of the drum. With a little practice, the message can be properly recorded within the 6 or 12 seconds allowed. The volume control on the record amplifier is set at approximately "70". This setting, however, may require variations to obtain the proper recording. With the drum stopped, the same patch cord is now placed in the jack of the playback amplifier. The busy switch is restored. A terminal block is provided on the back of the loop panel for making connections to the apparatus. A telephone can be connected to the output of the playback amplifier for monitoring purposes during or after recording.

Where several Automatic Recorder-Announcers are used in a network of exchanges, savings in initial cost of equipment can be realized by using a single record amplifier mounted in a carrying case with microphone and long patch cord, instead of mounting a record amplifier per machine (see Figure 5). It can be carried to each exchange location for erasing and recording the messages as required. Once a message has been recorded on the loop recorder there is no need for re-recording this message since the recording does not deteriorate with age or use.

Mounting—The loop recorder playback amplifiers and recording amplifiers are arranged for mounting on 19″ standard electronic mounting racks. To adapt this equipment to different sizes of relay racks in existing offices or new offices, suitable adaptor plates are available. However, 19½″ Automatic Electric relay racks can be easily re-drilled thus eliminating the need for adaptor plates.

It is quite likely that this same machine can be used for many other purposes in connection with telephone equipment.

Power—This equipment is arranged for operation on 115-volt, 60-cycle A.C., and power consumption is approximately 25 watts when the maximum amount of equipment is used. Where power is not dependable, a unit operating on the 48-volt exchange battery and generating 115-volt A.C. can be provided. The output of the playback amplifier is 8 ohms impedance for use in the same office, or 500 ohms for interoffice transmission of the recorded message.

The recording amplifier and playback amplifier are self-contained, that is, they both have their own power supply for tube heaters and plate supply. If additional messages or tracks are added, this arrangement simplifies additions. Heads and head mounting parts can be supplied for additions. The vacuum tubes employed are of types obtainable locally, and are removable from the front of the machine. The rear of the machine is accessible for servicing all parts. Only occasional oiling of bearings is required.

Type VML Automatic Recorder-Announcer (Variable Message Length)

As already explained above, the loop type of recorder is employed on both the time announcer for advertising purposes and on the 6-second Automatic Recorder-Announcer just described. For purposes requiring announcements of more than 6 or 12 seconds duration, this basic machine is also available for making recordings up to one minute, running at fast setting, or two minutes at slow setting. The appearance of the machine from the front is quite similar to the Type MCF Recorder-Announcer, except that on the rear of the machine, a lead screw arrangement has been provided, allowing a single recording head to spiral across the recording medium so as to obtain the longer recording period. Provision has been made on this type of machine so that variable length messages can be recorded; that is, the machine

will play back only the portion that has been recorded, automatically restting itself after each cycle of operation. In this type of machine, the controls are very similar, except that an additional panel is required for local or remote control. For local control, a key is operated during recording and released after the recording has been made. This key is the control means for automatically setting the loop recorder in record position and playing back only the portion of the message actually recorded. For remote control of the machine, a trunk can be simplexed—one leg for key control of recording, the other leg for recording lamp indication and the trunk for the audio circuit.

This Automatic Recorder-Announcer may be used for weather report announcing, or as an information announcer in factories and plants.

Type FML Automatic Recorder-Announcer (Fixed Message Length)

Several years ago Automatic Electric Company designed, built, and installed a special Automatic Recorder-Announcer for use by the Fire Departments of Park Ridge and Des Plaines, Illinois. These machines are employed for informing volunteer firemen of the location of fires. The recording of the fire location is made by an attendant in the fire station. Since then, other similar installations have been made.

This type of unit has now been re-designed to provide a third version of the Automatic Recorder-Announcer. When used in this manner, the loop recorder, recording amplifier, and playback amplifier require an additional panel incorporating the control features of the unit. This unit is usually installed on the main floor of the Fire Department. When it is also necessary to record from another section of the building, a small remote-controlled auxiliary unit can be provided. One pair of wires is required between the Fire Department and the telephone office (usually a 500-ohm line) for transmitting the audio output of the recorder unit to the office. Usually a conference circuit arrangement is provided at the central office, arranged so that the volunteer firemen can dial the conference number and receive instructions. This number is not listed and is thus available only to authorized callers. The recorder and all its components are mounted in a steel cabinet with front and rear doors. This is to prevent tampering and injury to the equipment. All the necessary controls, however, protrude through an opening in the front of the cabinet, making them accessible to the attendant making the recordings. Several automatic features are incorporated in this unit to simplify re-recording when it is used for fire location recording, or for other recording purposes in connection with telephone equipment.

Operation—In making a recording, a two-way toggle switch is momentarily operated which places the equipment in recording position automatically. A "recording lamp" indicates that the machine is in recording position. By means of a microphone, the desired recording is now made, and the lamp is extinguished after one revolution. The recording will continue to play until the same switch is momentarily operated in the opposite direction; this stops the rotation of the drum after it returns to its normal position. When the machine is used for fire reporting purposes, the volunteer firemen will dial an unlisted number to obtain the location of the fire. They are usually informed of the fire by a siren in the town or they may have special bells in each fireman's home which are operated by the fire department. Each time a new recording is made, the old recording is automatically erased by an erase head mounted in front of the record head. In emergency cases where the recorder is not operative, possibly due to power failure, a Monophone handset is provided inside the cabinet. Dry cells are included within the cabinet to provide transmission battery, making it independent from all other power sources. This machine may also have either a 6 or 12-second cycle, as desired.

Summary

This article explains a number of specific uses for the various types of Automatic Recorder-Announcers. Because of their flexibility of design, these machines can be readily applied to numerous other recorded message requirments. Telephone operating companies will no doubt realize the versatility of these machines and find other practical uses for them.

All of the Automatic Recorder-Announcers use the same basic components for recording and announcing.